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BIOLOGICAL EFFECTS OF NONIONIZING ELECTROMAGNETIC RADIATION. V0--ETC(U)

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Biological Effects of Nonionizing Electromagnetic Radiation

VOLUME II
NUMBER 4
JUNE, 1978

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A DIGEST OF CURRENT LITERATURE

A Quarterly Publication Produced for
National Telecommunications and Information Administration
and United States Navy

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THE FRANKLIN INSTITUTE RESEARCH LABORATORIES

Science Information Services Dept.

⑥
BIOLOGICAL EFFECTS
OF NONIONIZING ELECTROMAGNETIC RADIATION.
Volume II, Number 4.
A Digest of Current Literature.

⑦ Quarterly rept. Mar-Jun 78,

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⑯ Jun 78
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Literature Selected and Abstracted

by

Biomedical Group/Science Information Services Department

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Elena P. Saboe, Production Manager, Editor

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BIOLOGICAL EFFECTS OF NONIONIZING ELECTROMAGNETIC RADIATION

June, 1978 Volume II, Number 4

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PREFACE

Biological Effects of Nonionizing Electromagnetic Radiation is a publication researched and prepared by the Franklin Institute Research Laboratories, Science Information Services Department, under contract with the U.S. Navy and administered by the National Telecommunications and Information Administration.

This digest serves as a vehicle through which current documentation of research highlights on the biological effects and health implications of nonionizing electromagnetic radiation (microwave and radiofrequency radiation) are compiled, condensed, and disseminated on a regular basis. *Biological Effects of Nonionizing Electromagnetic Radiation* is intended to be a highly useful current awareness tool for scientists engaged in research or related activities. The great number and diversity of relevant publications make imperative the availability of this service to persons whose work requires that they keep abreast of current developments in the field.

Biological Effects of Nonionizing Electromagnetic Radiation is published quarterly. The issues of Volume II, and future volumes, will include materials received during the preceding three months. Each issue will include news items and announcements, a listing of meetings and conferences, abstracts of current literature, and a directory of current research. Materials for which full text is not available will be included as summary abstracts.

ABBREVIATIONS AND ACRONYMS

A, amp - ampere(s)
Å - angstrom(s)
BRH - Bureau of Radiological Health
C - centigrade
cm - centimeter(s)
cps - cycles per second
dB - decibel(s)
EPA - Environmental Protection Agency
FDA - Food and Drug Administration
g - gram(s)
G - Gauss
GHz - gigahertz
HEW - Health, Education, and Welfare
hr - hour
Hz - hertz
IEEE - Institute of Electronic and
Electrical Engineers
IMPI - International Microwave Power
Institute
IU - international unit(s)
J - joule(s)
k - kilo--
l - liter(s)
m - meter(s)
m - milli--
M - mega--
mho - unit of measurement of
conductivity
min - minute(s)
mo - month(s)

n - nano--
NBS - National Bureau of Standards
NIH - National Institutes of Health
NSF - National Science Foundation
NIOSH - National Institute for
Occupational Safety and Health
NTIS - National Technical Information
Service
Oe - oersted(s)
OSHA - Occupational Safety and Health
Administration
OTP - Office of Telecommunications
Policy
PHS - Public Health Service
rad - radiation absorbed dose
R - roentgen(s)
rpm - revolutions per minute
sec - second(s)
USAFSAM - U.S. Air Force School of
Aerospace Medicine
USDA - U.S. Department of Agriculture
UV - ultraviolet
V - volt(s)
VA - Veterans Administration
W - watt(s)
Wb - Weber(s)
WHO - World Health Organization
wk - week(s)
wt - weight
yr - year(s)

μ - micro--

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NEWS ITEMS

MICROWAVES AFFECT MONKEY BEHAVIOR

Scientists at BRH's Division of Biological Effects have found that microwave exposure can alter monkey's behavior acquisition, memory, alertness, and rewarded performance. They also found that monkeys treated with neuroactive drugs were more sensitive to the effects of microwave radiation than were un-drugged monkeys. The results were presented in February, 1977 at the Bureau's Symposium on Biological Effects of Radiofrequency/Microwaves and have been published in the symposium proceedings. The publication is available from the Superintendent of Documents.

BRH Bull 7(5): 2-3; 1978

because electromagnetic radiation emitted by the devices presented a hazard of cataract formation. Benewitz stated that "the vast majority of all employees may work in safety upon the VDT machines at the *Times*." He added, "When all of the worst emission settings for density, brightness and keyboard depressions were combined (a situation which does not occur with frequency it might be expected) nevertheless, the medical panel would not find in the resulting emission levels an ocular cataract hazard."

Labor & Personnel Relations Bull (6496): 77-89; 1978

BRH APPROVES MICROWAVE OVEN CORRECTIVE ACTION PLAN

The BRH has approved a corrective action plan submitted by Hobart for 4,800 commercial microwave ovens, models 900 and 1250, manufactured prior to August, 1974. The ovens were found in noncompliance because of possible microwave leakage exceeding the limits specified in the microwave oven performance standard. Hobart service personnel will readjust the door latch mechanisms, tighten screws as needed, and apply "Locktite" to the screws to assure permanent tightness. Each oven will be checked for leakage before and after the repair is made. Owners will be notified of the problem through a letter to be delivered by the service representative at the time of repair, and the repairs will be made free of charge.

BRH Bull 7(5): 4; 1978

BRH COMPLIANCE CASE LISTING AVAILABLE

A listing of recent BRH compliance cases involving electronic products found defective or in noncompliance with applicable performance standards is available as a supplement to the BRH Bulletin. The supplement updates an earlier listing published in July, 1976 and enumerates most of the defect and noncompliance cases in progress as well as cases initiated and completed since July, 1976.

BRH Bull Suppl 7 pp; March 1978

ARBITRATOR DECLARES VIDEO DISPLAY TERMINALS SAFE

Video display terminals (VDTs) in use at the *New York Times* "do not pose any ocular radiant energy hazard" to employees assigned to work on them, concluded arbitrator, Maurice C. Benewitz, in a February 8, 1978 decision. The arbitration resulted from a grievance filed by the Newspaper Guild of New York alleging that the health and safety of employees assigned to the VDTs might be endangered

PASSIVE NONIONIZING RADIATION MONITOR DEVELOPED

Researchers at Iowa State Univ. have developed a novel, entirely passive device to monitor nonionizing radiation. The device utilizes the temperature-dependent light scattering properties of cholesteric liquid crystals--the substance used in passive digital thermometers. The liquid crystal, painted on plastic disks, indicates power densities as low as 1 mW/cm² without batteries, moving parts, circuits, or meters. The developers point out that the radiation monitor can be inexpensively produced in large quantities.

Microwaves 16(8): 10, 12; 1977

MOTORISTS FIND ELECTRIC FIELDS STIMULATING

Exposure to electric fields improves driving ability, according to a team of Munich scientists. Subjects were placed in a simulated vehicle and exposed to an artificial atmospheric long-wave electric field. It was found that unstable persons were influenced positively to a greater degree than stable persons by the artificial field. The investigators speculate that the employment of artificial atmospheric electric fields could have a favorable effect on general traffic safety, particularly during tiring long distance journeys. A great deal of research is still necessary in this area. Nevertheless, motorists may one day be equipping their vehicles with a type of long-wave transmitter.

Dtsch Forschungsdienst 16(8): 3; 1977

SCIENCE COURT TO SETTLE RADIATION HAZARD CONTROVERSY

A raging controversy over plans to build a 400-kV power line in the state of Minnesota has prompted the state's governor to accept the idea of convening a science court to settle the radiation hazard question. The line, which would stretch 180 miles across the state, has evoked violent opposition from farm groups that believe the line will produce hazardous quantities of electromagnetic radiation. Various state bodies, including the environmental quality board and the state supreme court, have

NEWS ITEMS

approved construction of the line, but farmers remain unconvinced. The science court, funded by the Ford foundation and the NSF, would have no legal standing since the case is legally settled. Rather, it would rely on the prestige of its participants and the evenhandedness of its proceedings to obtain public approval of its findings. The state environmental quality board may, however, re-open the case if it finds that a review is warranted by new evidence.

New Scientist 77(26): 237-238; 1978

Biological Effects of Nonionizing Electromagnetic Radiation 11(4), June, 1978

Defense Department. The panel will have the benefit of three days of testimony given by experts last summer before the Senate subcommittee on commerce, science, and transportation, many of whom will be recalled. Also expected to participate, according to a subcommittee spokesman, are such microwave critics as Paul Brodeur and ophthalmologist, Dr. Milton Zaret, who links low-level microwave radiation with certain forms of cataracts.

Microwaves 17(2): 23; 1978

MICROWAVE RADIATION STANDARD MAY BE INADEQUATE

With the American National Standards Institute's (ANSI) advisory microwave exposure standard due for review in 1979, mounting evidence suggests that the 10 mW/cm² limit may be inadequate. In one recently completed study funded by the EPA and performed by the Stanford Research Institute, Menlo Park, California researchers found that "of the offspring of eight monkeys irradiated at the ANSI standard of permissible radiation, six died within six months of birth. In the control group none of the offspring died."

New Scientist 77(1085): 69; 1978

MICROWAVE TREATMENT PRESERVES MEAT

Microwave ovens destroy bacteria on fresh meat and poultry, thereby increasing the foods' shelf life, according to Kansas State Univ. food scientist, Frank Cunningham. If newly purchased meat is placed in a microwave oven for 10 sec, Dr. Cunningham says, it will usually keep a day or two longer in the refrigerator than it would have otherwise. Dr. Cunningham found that a 10- to 15-sec exposure to microwaves considerably reduces bacterial counts in fresh meat. Longer treatments are not recommended because they cause moisture loss and higher temperature in the meat. Dr. Cunningham and some students are presently studying the effects of microwave radiation on pure cultures of cryophilic bacteria.

Chem Eng News 56(10): 50; 1978

CONGRESS TO INVESTIGATE MICROWAVE BIOEFFECTS

The health and environment subcommittee of the House Committee on Interstate and Foreign Commerce plans an extensive probe on radiation beginning with the health effects of ionizing radiation. The panel, headed by Rep. Paul Rogers, expects to finish in mid-summer with an examination of high and low level non-ionizing radiation. Due for a dose of attention are microwave ovens, dental and medical equipment, and probably radiation hazards at the

DOCTORS DISPUTE THERAPEUTIC VALUE OF MAGNETS

Specialists in rheumatic diseases at the Medical Research Council, London, England warn that magnetic necklaces, claimed to relieve the wearer of rheumatism and other ailments, should be treated with the same suspicion as copper bracelets. The devices, available in England, are sold on the basis that there is a "magnetic field deficiency syndrome" in the human body that needs to be made up, and that a strong magnetic effect "enhances the blood circulation." The manufacturer's advertising literature refers to "research at leading Japanese hospitals" as establishing "remarkable results on the effectiveness of the necklace." However, a doctor specializing in rheumatic diseases at the Medical Research Council cautioned: "There are no theoretical grounds to suggest that magnetism plays any part in the treatment of rheumatic disorders. There is no evidence published in acknowledged Western medical journals to support the use of magnetism." The doctor added that rheumatic pains often disappear spontaneously. "If a period of remission coincides with anything out of the ordinary, be it wearing a magnetic necklace or a copper bracelet or even standing on your head, it is tempting to think that you've at last found a cure, when in fact you've found only a coincidence."

New Scientist 77(1091): 506; 1978

RADAR SYSTEM SPARKS DEBATE OF MICROWAVE EXPOSURE STANDARD

A team of U.S. Air Force radiation experts met in January with Cape Cod residents concerned about the possible radiation hazards posed by a defensive radar system under construction at Otis Air Force Base, Massachusetts. The radar system, known as PAVE PAWS (Precision Acquisition of Vehicle Entry, Phased Array Warning System) is designed to detect sea launched ballistic missiles. Lt. Col. Paul McEachern, who presented the case for the Air Force, assured the residents that "the power densities will be well below the values at which any health impact will occur. The predicted radiation levels are completely safe." McEachern explained that "safe" was based on the federal safety standard of 10 mW/cm². Harvard biologist, Dr. George Wald, stated, however, that the American standard is based on the level at which heating of tissues occurs and does

not account for possible nonthermogenic health hazards. Another Harvard scientist stressed the need for further study of nonthermal effects associated with low-level microwave exposure, especially in the central nervous system. She observed that the exchange of ions in neural membranes could be disturbed by very weak electric fields. "We are talking about minute disturbances in cell membranes which could very well be cumulative."

New Scientist 77(1088): 302; 1978

RADIATION CONTROL CONFERENCE
EXPLORES MICROWAVE BIOEFFECTS

The Conference of State Radiation Control Program Directors held its Tenth Annual National Conference on Radiation Control April 30 to May 4, 1978 in Harrisburg, Pennsylvania. The conference was sponsored jointly by the BRH, EPA's Office of Radiation Programs, and the Nuclear Regulatory Commission. Issues facing the sponsoring agencies and the states in the reduction and control of public exposure to unnecessary radiation were explored. Also discussed were the current status of microwave bioeffects research, findings of environmental studies, and the need for standards. The featured speaker, Paul Brodeur, author of *The Zapping of America*, presented a talk entitled "The Unmet Challenge in Radiation Control."

BRH Bull 12(4): 3-4, 1978

ITEMS FROM THE COMMERCE BUSINESS DAILY

RESEARCH ON THE NATURE OF ELECTROMAGNETIC FIELD INTERACTION WITH BIOLOGICAL SYSTEM FUNCTION.

The Office of Naval Research, Arlington VA will negotiate with Randomline, Inc., Huntingdon Valley, PA for the above study. (February 21, 1978)

FABRICATION OF A MICROWAVE APPLICATOR TO DIAGNOSE AND TREAT CANCER USING NONINVASIVE TECHNIQUES.

The National Aeronautics and Space Administration Industry Assistance Office, Langley Research Center, Hampton, VA will negotiate with Microwave Associates, Inc., Burlington, MA for the above study. (March 6, 1978)

FURTHER RESEARCH ON MICROWAVE EFFECTS.

The office of Naval Research, Arlington, Virginia has contracted with the Board of Regents of the University of Washington, Seattle, Washington, for the above study. (April 3, 1978)

MEETINGS AND CONFERENCES

CONFERENCE ON PRECISION ELECTROMAGNETIC MEASUREMENTS

Date: June 26-29, 1978
Place: Ottawa, Canada: Government Conf. Cent.
Sponsor: Inst. Electrical & Electronics Engineers--Instrumentation and Measurement Group; National Bureau Standards; International Union of Radio Science--U.S. National Committee
Requests for Information: K. Charbonneau, Executive Secretary, C/O National Research Council of Canada, Ottawa, Canada K1A 0R6

IEEE MTT-S INTERNATIONAL MICROWAVE SYMPOSIUM

Date: June 27-29, 1978
Place: Ottawa, Canada: Chateau Laurier Hotel
Sponsor: Inst. Electrical & Electronics Engineers, (Microwave Theory & Technique)
Requests for Information: S. J. Kubina, Publicity Chairman, Electrical Engineering Dept., Concordia Univ., 7141 Sherbrooke St. W., Montreal, Canada H4B 1R6

1978 SYMPOSIUM ON ELECTROMAGNETIC FIELDS IN BIOLOGICAL SYSTEMS

Date: June 27-30, 1978
Place: Ottawa, Canada: Holiday Inn (Centre)
Sponsor: Microwave Theory & Techniques Society, Inst. Electrical & Electronic Engineers, International Microwave Power Inst. with the cooperation of U.S. Committee for URSI and Canadian Commission A of URSI
Requests for Information: M. H. Repacholi, Local Arrangements Chairman, Dept. National Health & Welfare, Environmental Health Centre, Room 233, Tunney's Pasture, Ottawa, Canada K1A 0L2

Selected Bibliography of Papers to be Presented:

RAT HYPOTHALAMIC TEMPERATURES DURING WHOLE BODY EXPOSURE TO 2450 MHz AND 2800 MHz MICROWAVES AT LOW POWER DENSITIES.
G. Brainard, E. Postow, M. DeSantis, J. Parker

EFFECT OF 2450 MHz MICROWAVE IRRADIATION ON PERMEABILITY OF THE BLOOD-BRAIN BARRIER TO MANNITOL IN THE RAT.
E. Preston, E. Vavasaur, H. Assenheim

NEUROENDOCRINE FUNCTION IN RHESUS MONKEYS EXPOSED TO PULSED MICROWAVE RADIATION.
W. Lotz

ACTIVITY-RELATED ALTERATIONS IN GLUCOSE CONSUMPTION AT AUDITORY NUCLEI OF THE RAT

DURING EXPOSURE TO MICROWAVE RADIATION: AUTORADIOGRAPHIC EVIDENCE USING [¹⁴C] 2-DEOXY-D-GLUCOSE.
B. Wilson, J. Zook, W. Joines, J. Casseday

EFFECTS OF RF ENERGY ON THE EEG OF RABBIT.
S. Takashima, B. Onaral, H. Schwan

HISTOPATHOLOGICAL CHANGES IN THE RABBIT LENS DURING DEVELOPMENT OF MICROWAVE CATARACT.
R. Carpenter

THERMAL CATARACT FORMATION IN RABBITS.
P. Kramar, C. Harris, A. Guy

MICROWAVE IRRADIATION OF GUINEA PIGS AT 2.45 GHz.
E. Ferri, M. Foti

INCIDENCE OF SISTER CHROMATID EXCHANGE IN BONE MARROW CELLS OF THE MOUSE FOLLOWING MICROWAVE EXPOSURE.
D. McRee, G. Livingston, G. MacNichols

SURVIVAL STUDIES OF MAMMALIAN CELLS EXPOSED TO RADIOFREQUENCY WAVES AT Elevated TEMPERATURES.
G. Li, I. van Kersen, K. White, G. Hahn, E. Tanabe, V. Vaguine, N. Williams

8.6 GHz ELECTROMAGNETIC RADIATION EFFECT ON *ESCHERICHIA COLI* REPAIR DEFICIENT MUTANT UNDER CONTROLLED TEMPERATURE.
S. Dutta, M. Hossain

EFFECTS OF 2450 MHz MICROWAVES ON MOUSE TESTICULAR CYTOLOGY.
A. Cairnie, K. Harding, H. Assenheim, K. Leach, L. Prud'homme-Lalonde

RADIOFREQUENCY RADIATION AND ENZYME KINETICS.
R. Albanese, D. Cohoon

TECHNIQUES FOR PRODUCING STANDARD EM FIELDS FROM 10 KHz to 10 GHz FOR EVALUATING RADIATION MONITORS.
E. Larsen

A CELL CULTURE EXPOSURE SYSTEM FOR IN-FIELD OPTICAL OBSERVATION OF BIOLOGICAL RESPONSE:
L. Pearson, J. Sisken, J. Linstrom

A COMPACT GAUSSIAN-BEAM LAUNCHER FOR MICROWAVE EXPOSURE STUDIES AT 2450 MHz.
P. Neeklakantaswamy, K. Gupta, D. Banerjee

TEMPERATURE CONTROLLED CAVITY APPLICATOR FOR RADIOFREQUENCY WAVE IRRADIATION OF MAMMALIAN CELLS *IN VITRO*.
E. Tanabe, V. Vaguine, N. Williams, C. Li, G. Hahn

EVALUATION OF LYMPHOCYTE FUNCTION IN MICE EXPOSED REPEATEDLY TO 2450 MHz (CW) MICROWAVE RADIATION.
R. Smialowicz, M. Riddle, P. Brugnolotti, T. Ward, J. Kinn

MEETINGS AND CONFERENCES

Biological Effects of Nonionizing Electromagnetic Radiation II(4), June, 1978

ALTERATION OF IN VIVO LYMPHOCYTE MIGRATION BY WHOLE-BODY MICROWAVE HYPERTERMIA.
R. Liburdy

FETAL RAT DEVELOPMENT IN RESPONSE TO MICROWAVE RADIATION.
M. Chernovetz, D. Levinson, D. Justesen

ADAPTATION TO MICROWAVE EXPOSURE AS A FUNCTION OF POWER DENSITY AND AMBIENT TEMPERATURES IN THE RAT.
R. Johnson, S. Mizumori, R. Lovely

INDUCTION OF TERATOGENIC EFFECTS IN RATS BY 27.12 MHz RF RADIATION.
D. Conover, J. Lary, E. Foley

BEHAVIORAL AND PHYSIOLOGICAL EFFECTS OF CHRONIC LOW LEVEL 2450 MHz MICROWAVE RADIATION IN RATS.
J. D'Andrea, O. Gandhi, L. Astle, C. Durney, J. Lords, C. Johnson

ALTERATION OF BEHAVIORAL AND BIOCHEMICAL PARAMETERS DURING AND CONSEQUENT TO 500 μ W/cm² CHRONIC 2450 MHz MICROWAVE EXPOSURE.
R. Lovely, R. Johnson, M. Mathews

FAILURE OF RATS TO ESCAPE FROM AN INTENSE 918-MHz MICROWAVE FIELD.
D. Carroll, D. Levinson, R. Clarke, D. Justesen

SHUTTLEBOX SIDE PREFERENCE AS MEDIATED BY PULSED MICROWAVE AND CONVENTIONAL AUDITORY CUES.
D. Hjeresen, S. Doctor, R. Sheldon

DISRUPTION OF BEHAVIOR IN MAMMALS OF THREE DIFFERENT SIZES EXPOSED TO MICROWAVES: EXTRAPOLATION TO LARGER MAMMALS.
J. de Lorge

CONDITIONED TASTE AVERSION IN RATS EXPOSED TO 2450 MHz CW MICROWAVES.
W. Williams

EFFECTS OF HIGH INTENSITY 60-Hz ELECTRIC FIELDS ON RATS.
D. Koltun, J. Seto, D. Weissfeld, Y. Seto

EVOKED POTENTIAL STUDY OF RATS CHRONICALLY EXPOSED TO 60 Hz, 10 KV/m ELECTRIC FIELD.
C. Walker, D. Weissfeld, D. Koltun, Y. Seto

EFFECTS OF 60 Hz ELECTRIC FIELDS ON THE BEHAVIOR OF RATS.
D. Hjeresen, J. Chandon, R. Phillips

EFFECT OF HIGH STRENGTH 60-Hz ELECTRIC FIELDS ON GENERAL AND REPRODUCTIVE ENDOCRINOLOGY OF MALE RATS.
M. Free, L. Smith, R. Jaffe, W. Kaune, R. Phillips

THE EFFECTS OF CHRONIC EXPOSURE TO A 60-Hz ELECTRIC FIELD ON SYNAPTIC TRANSMISSION IN THE MAMMALIAN NERVOUS SYSTEM.
R. Jaffe, W. Kaune, R. Phillips

ELECTROMAGNETIC MEDIATED HORMONAL EFFECTS: THEORETICAL CONSIDERATIONS AND EXPERIMENTATION.
S. Hsieh, D. Weissfeld, D. Koltun, J. Lyman-grover, Y. Seto

MONITORING OF ARTERIAL WALL MOVEMENTS BY MICROWAVE DOPPLER RADAR.
S. Stuchly, M. Goldberg, A. Thansandote

USE OF MICROWAVE POWER IN NEONATAL CARDIAC SURGERY.
C. Johnson, C. Durney, D. Wong, D. Westenskow

LOCAL MICROWAVE-INDUCED HYPERTERMIA FOR CANCER THERAPY.
E. Bowers, J. Walsh, E. Douple, J. Strohbehn, R. Gibson

HEATING PATTERNS OF A NEW MICROWAVE HYPERTERMIA APPLICATOR.
T. Sandhu, R. Johnson, G. Kantor, H. Kowal

A NEW 915 MHz DIRECT CONTACT APPLICATOR WITH REDUCED LEAKAGE.
G. Kantor, D. Witters

THE EFFECT OF LOCAL TUMOR HYPERTERMIA ON THE GROWTH OF SOLID TUMOR IN MICE.
R. Magin

RADIOFREQUENCY (0.5 & 3.3, MHz) CURRENT INDUCTION OF LOCALIZED HYPERTERMIA IN TISSUES. SOME EXAMPLES.
T. Cetas, W. Connor, D. Cooper, R. Miller, H. Roth

FINITE-ELEMENT CALCULATIONS OF ELECTROMAGNETIC ABSORPTION BY BIOLOGICAL BODIES.
P. Barber, C. Johnson, C. Yeh

HEAD RESONANCE: NUMERICAL SOLUTIONS AND EXPERIMENTAL RESULTS.
J. Hagmann, O. Gandhi, J. D'Andrea, J. Chatterjee

SURFACE INTEGRAL EQUATION SOLUTIONS FOR FIELDS IN BIOLOGICAL BODIES OF REVOLUTION.
Te-Kao Wu

THERMOGRAPHIC COMPARISON OF TEMPERATURE PROBES USED IN MICROWAVE DOSIMETRY STUDIES.
R. Olsen, W. Hammer

TRANSMISSION COEFFICIENT OF NEAR ZONE MICROWAVES INTO PLANAR BIOLOGICAL TISSUES: HORIZONTAL DIPOLES.
A. Kamal, K. Badwaihy and E. Hashish

TEMPERATURE RISE IN TISSUE SPHERES INDUCED BY MICROWAVE RADIATION: A GREENS FUNCTION APPROACH.
H. Kritikos, K. Foster, H. Schwan

IMPLICATIONS OF THE RADIOFREQUENCY RADIATION DOSIMETRY HANDBOOK (SECOND EDITION).
S. Allen, C. Durney, C. Johnson

NUMERICAL MODELING OF THREE-DIMENSIONAL ARBITRARILY-SHAPED HETEROGENEOUS BIOLOGICAL BODIES
UNDER COMPLEX EXCITATIONS.
J. Wang, F. Cain, E. Burdette

NUMERICAL CALCULATION OF MICROWAVE ABSORPTION
IN ARBITRARY GEOMETRY WITH APPLICATION TO A
MODEL OF MAN.
S. Neuder, R. Kellog

THERMOGRAPHIC ANALYSIS OF HUMAN PHANTOM MODELS
EXPOSED TO EMISSION FROM A MICROWAVE OVEN.
R. Prucha, L. Belden

AN EMPIRICAL FORMULA FOR CALCULATING THE SAR
OF PROLATE SPHEROIDAL MODELS OF HUMANS AND
ANIMALS IRRADIATED BY PLANEWAVES.
C. Durney, M. Iskander, H. Massoudi, C. Johnson

APPROXIMATE ANALYSIS OF PLANEWAVE IRRADIATION
OF MAN NEAR A GROUND PLANE.
M. Iskander, C. Durney, H. Massoudi, C. Johnson

IMPI MICROWAVE POWER SYMPOSIUM: 1978

Date: June 28-30, 1978
Place: Ottawa, Canada: Chateau Laurier Hotel
Sponsor: International Microwave Power
Institute (IMPI)
Requests for Information: W. Wyslouzil, Local
Arrangements Chairman, Electrical Engineering
Div., National Research Council of Canada,
Ottawa, Canada K1A 0R8

OPEN SYMPOSIUM ON BIOLOGICAL EFFECTS OF ELECTRO-
MAGNETIC WAVES

Date: August 1-8, 1978
Place: Helsinki, Finland
Sponsor: International Radiation Protection
Association (IRPA) and Commissions A & B
Requests for Information: S. W. Rosenthal,
Polytechnic Institute of New York, Farming-
dale, NY 11735

EIGHTH EUROPEAN MICROWAVE CONFERENCE

Date: September 4-7, 1978
Place: Paris, France: Hotel Meridien
Sponsor: Societe des Electriciens, des Elec-
troniciens et Radioelectriens (Groupement
des Industries Electriques)
Requests for Information: Professor E. Constant,
Conference Chairman, Centre Hyperfrequencies et Semi-
conducteurs, Universite des Sciences et Techniques,
BP 36, 59650, Villeneuve d'Ascq, France

AMERICAN ACADEMY OF OCCUPATIONAL MEDICINE: Thirteenth
Annual Meeting

Date: September 20-22, 1978
Place: Williamsburg, VA
Sponsor: American Academy of Occupational
Medicine (AAOM)
Requests for Information: AAOM, 150 N. Wacker
Dr., Chicago, IL 60606

NINETEENTH INTERNATIONAL CONGRESS ON OCCUPATIONAL
HEALTH

Date: September 25-30, 1978
Place: Dubrovnik, Yugoslavia
Sponsor: Permanent Commission & Internation-
al Assoc. of Occupational Health (PCIAOH)--
organized by Assoc. of Occupational Health
of Yugoslavia (AOHY) & Inst. for Medical
Research & Occupational Health
Requests for Information: Professor M. Saric,
Inst. for Medical Res. & Occupational Health,
41000 Zagreb, 158 Mose Pijade, POB 291,
Yugoslavia

WESTERN OCCUPATIONAL HEALTH CONFERENCE

Date: October 12-14, 1978
Place: Los Angeles, CA: Hyatt Regency Hotel
Sponsor: American Industrial Hygiene Assoc.,
Health Physics Society; Western Occupational
Medical Assoc. (WOMA); Western Assoc. Indus-
trial Nurses; American Society Safety En-
gineers
Requests for Information: B. H. Bravinder
WOMA, Box 201, Alamo, CA 94507

MILITARY MICROWAVES 78

Date: October 25-27, 1978
Place: London, England: Wembley Confer. Cent.
Sponsor: EMC Management Committee, IEE,
IEE
Requests for Information: Dr. D. E. N. Davies
University College, London, England

ENGINEERING IN MEDICINE & BIOLOGY: Thirty-first Annual
Conference

Date: November 6-9, 1978
Place: Atlanta, GA: Marriott
Sponsor: Alliance for Engineering in Medicine
and Biology (AEMB)

MEETINGS AND CONFERENCES

Biological Effects of Nonionizing Electromagnetic Radiation II(4), June, 1978

Requests for Information: Mrs. P. I. Horner,
AEMB, Suite 1350, 5454 Wisconsin Ave., Chevy
Chase, MD 20015

INTERNATIONAL MICROWAVE SYMPOSIUM

Date: March 30-April 2, 1979
Place: Orlando, FL: Sheraton Twin Towers
Sponsor: Inst. Electrical & Electronic En-
gineers (IEEE)--Microwave Theory & Techniques
Group
Requests for Information: R. E. Henning,
College of Engineering, Univ. South Florida,
Tampa, FL 32620

SIXTH INTERNATIONAL CONGRESS OF RADIATION RESEARCH

Date: May 13-19, 1979
Place: Tokyo, Japan
Sponsor: International Assoc. for Radiation
Research, Science Council of Japan, Japanese
Assoc. for Radiation Research
Requests for Information: Professor S. Okada,
Secretary-General 6th International Congress,
Dept. Radiation Biophysics, University of
Tokyo, Hongo-Bunkyo-ku, Tokyo, 113 Japan

CURRENT RESEARCH

0258 THE CENTRAL NERVOUS SYSTEM AS AN IMMUNOLOGICALLY PRIVILEGED SITE. Morantz, R. A.; Rengachary, S. (Veterans Admin. Hosp., 4801 Linwood Blvd., Kansas City, MO 64128).

Microwave-induced hyperthermia as a therapy for brain tumors is being investigated in rats. Initial experiments found that microwave radiation can induce a seizure discharge in rats with a brain tumor. Further experiments will assess the effect of multiple courses of hyperthermia on rat survival. (8/77-7/78)

Supporting Agency:U.S. Veterans Admin.

0259 QUANTIFICATION & MEASUREMENT OF INTERNAL ELECTROMAGNETIC FIELDS INDUCED IN FINITE BIOLOGICAL BODIES BY NONUNIFORM ELECTROMAGNETIC FIELDS. Chen, K. (Michigan State Univ., Sch. Engineering, Engineering Building, Dept. Electrical Engineering & System Science, East Lansing, MI 48824).

A theoretic basis will be developed for quantification and measurement of internal electromagnetic fields induced in finite biologic bodies by non-uniform electromagnetic fields. Experimental confirmation will be sought by use of implantable probes in simulated models. A theoretic study of implanted probes and their response within the medium will be made. The Army is using electromagnetic radiation to provide communication links; to probe the battle environment for enemy presence, equipment, and activities; to control defensive ordnance; and to control guidance of ordnance. Individual and cumulative levels of these radiated energies are becoming a considerable concern because of their effects on the natural environment and on man. The theoretic method will be based on numeric solution of a tensor integral equation quantifying the internal electromagnetic field induced in a finite, heterogeneous biologic body by an incident, non-uniform electromagnetic field. In this method the body is subdivided into a selected number of small sub-volumes, and the individual electric properties determined. Measurements with sample probes immersed in various simulant media will determine parameters for testing the theoretic derivations of probe interactions. (10/77-9/78)

Supporting Agency:U.S. Dep. Def., Army

0260 BEHAVIORAL EFFECTS OF 915 MHz MICROWAVE RADIATION IN RATS. Dandrea, J. A.; Ganchi, O. P.; Gehrich, J. L.; Astle, L. (Utah Higher Education System, Sch. Medicine, Dept. Medicine, 1400 E. 2nd St., Salt Lake City, UT 84112).

Long-Evans rats are being exposed to 915 MHz microwave radiation at a power density of 5 mW/cm^2 , 8 hr/day, 5 days/wk for 16 wk. Fifteen of the twenty rats are given nocturnal access to running wheels. The remaining five rats are trained to press a lever for food pellet reward after each radiation period. Daily measurements of the animals' behavioral performance, body mass, and food and water intake are being recorded. Hematology, serum chemistry, and

urine indices will be assessed. In addition, electroencephalographic activity will be assessed after the radiation sequence is completed. (10/77-9/78)

Supporting Agency:HEW, PHS, NIH, Natl. Inst. Environmental Health Sciences

0261 MICROWAVE METHODS OF LUNG WATER MEASUREMENT. Durney, C. H.; Bragg, D. G.; Iskander, M. F.; Shoff, D. J. (Utah Higher Education System, Sch. Engineering, Dept. Electrical Engineering, 1400 E. 2nd St., Salt Lake City, UT 84112).

The feasibility of measuring the total fluid content in the lung by measuring reflection of microwave energy applied to the thorax or the transmission of microwave energy through the thorax will be determined. Microwave measurements will be made on phantoms simulating the thorax and on dogs in which pulmonary edema has been induced. (12/77-11/78)

Supporting Agency:HEW, PHS, NIH, Natl. Heart Lung & Blood Inst.

0262 THE EFFECTS OF PRENATAL EXPOSURE TO 915 MHz MICROWAVE RADIATION IN RATS. Lovely, R.; Guy, A. (Univ. Washington, Sch. Medicine, Dept Rehabilitation Medicine, 500 17th Ave., Seattle, WA 98122).

Wistar rats were exposed in utero to 915 MHz microwave radiation at a power density of 5 mW/cm^2 for a total of 380 hr. Behavior of the rats was observed from birth through maturation. (10/77-9/78)

Supporting Agency:HEW, PHS, NIH, Natl. Inst. Environmental Health Sciences

0263 EFFECTS OF 2450 MHz MICROWAVE RADIATION IN RATS. Lovely, R.; Guy, A. (Univ. Washington, Sch. Medicine, Dept. Rehabilitation Medicine, 500 17th Ave., Seattle, WA 98122).

Wistar rats will be exposed to 2,450 MHz microwave radiation at a power density of 5 mW/cm^2 , 8 hr/night for 3 mo. Changes in urinary ketosteroid levels, glutathione levels, and serum cholinesterase activity will be followed during exposure and a 2-mo recovery period. Changes in behavioral response to an attention vigilance task will also be studied. (10/77-9/78)

Supporting Agency:HEW, PHS, NIH, Natl. Inst. Environmental Health Sciences

0264 RADIOfREQUENCY AND HEAT ENERGY FOR SEED TREATMENT. Nelson, S. O.; Stetson, L. E. (Univ. Nebraska, U.S. Dept. Agriculture, Agricultural Engineering Res. Div., Lincoln, NB 68503).

The use of radiofrequency (RF) electric energy and heat energy for treatment of seed to improve germin-

ation characteristics will be investigated. Hot-air seed-treating equipment will be devised, and the results of heat and RF treatment on germination response of alfalfa and red clover seed will be compared. The economic feasibility of these methods for reducing hard-seed percentages will be determined. Other kinds of seed will be exposed to RF treatments under known frequency, field-intensity, moisture-content, and temperature conditions to learn what kinds of seed respond favorably. Earlier studies showed that germination of several kinds of seed can be improved by exposures of a few seconds to RF electrical treatments in the 10-40-MHz frequency range. These treatments, as well as infrared radiation, have been especially effective for safely reducing hard-seed percentages in alfalfa seed lots and in other hard-seeded legumes without causing the deterioration in seed quality that accompanies mechanical scarification processing. In limited tests, hot-air-oven seed treatment and RF exposures at microwave frequencies also effectively lowered hard-seed percentages in alfalfa seed lots. (10/76-9/77)

Supporting Agency: U.S. Dep. Agriculture

0265 EFFECT OF ENVIRONMENTAL AGENTS ON ONTOGENESIS AFTER PARENTAL EXPOSURE. Staples, R. E.; Nawrot, P.; Cook, R. O. (U.S. Dept. HEW, Natl. Inst. Environmental Health Sciences, Environmental Toxicology Lab, Durham, NC 27709).

This project will determine the developmental toxicity and teratogenic potential of selected environmental agents on mammals by application of the test agents to the parent(s) before mating or to the dam during gestation. Studies will employ various types of noise up to 130 dB, microwaves, and solvents. (10/76-9/77)

0266 EFFECTS OF MICROWAVE EXPOSURE ON IMMUNE DEFENSE MECHANISMS IN PERINATAL RATS. Smialowicz, R. J.; Kinn, J. B.; Liddle, C. G. (EPA, Experimental Biology Div., Durham, NC 27711).

Separate groups of rats were exposed perinatally to 2,450 and 425 MHz microwave radiation for 4 hr/day. Rats were sacrificed at 20 and 40 days of age, and blood counts were performed. In addition, the in vitro blastogenic response of blood and lymph node lymphocytes was measured by ³H-thymidine incorporation into DNA following stimulation of the cells with T- or B-lymphocyte mitogens. (10/77-9/78)

Supporting Agency: EPA

0267 INTERACTION OF ELECTROMAGNETIC FIELD WITH BIOLOGICAL SYSTEMS. Chen, K. (Michigan State Univ., Sch. Engineering, Engineering Building, Dept. Electrical Engineering and Systems Science, East Lansing, MI 48824).

Theoretic methods for determining the internal electromagnetic field inside a biologic body of arbitrary shape will be developed. In addition,

an experimental measurement program will be conducted using simulated biologic models. A digital computer program will be used to quantify the induced electric field inside the biologic bodies in order to obtain theoretic predictions. The theoretic methods will also be applied to study possible therapeutic and diagnostic applications, such as, local heating in hyperthermia and non-invasive diagnostics. (2/78-1/79)

Supporting Agency: NSF, Div. Engineering

0268 EFFECTS OF PRE-CONCEPTION EXPOSURE TO MICROWAVES ON THE LENGTH OF GESTATION. Berman, E. (EPA, Experimental Biology Div., Durham, NC 27711).

Virgin adult female mice were exposed to 2.45 GHz radiation for 30 days, bred, and examined for length of gestation. Pilot studies indicated that the application of 10 mW/cm² for 30 days increased the length of gestation up to 10%. (10/76-9/77)

Supporting Agency: EPA

0269 TERATOLOGICAL STUDY OF MICE EXPOSED TO MICROWAVES. Berman, E.; Carter, H. (EPA, Health Effects Res. Lab., Durham, NC 27711).

Newly bred virgin CD1 mice were exposed to 2,450 MHz microwave radiation at power levels of 3, 4, 10, and 30 mW/cm² for 100 min/day through gestation. Animals were sacrificed, and fetuses examined for morphologic effects of the radiation. (10/77-9/78)

Supporting Agency: EPA

0270 BEHAVIORAL EFFECTS OF 2450 MHz MICROWAVE RADIATION IN RATS. Lovely, R.; Guy, A. (Univ. Washington, Sch. Medicine, Dept. Rehabilitation Medicine, 500 17th Ave., Seattle, WA 98122).

Wistar rats are being exposed to 2,450 MHz microwave radiation at a power density of 500 μ W, 7 hr/day for 3 mo in anechoic chambers. Behavioral parameters are being studied during exposure and will continue during the recovery period in an attempt to replicate previous Russian studies. (10/77-9/78)

Supporting Agency: HEW, PHS, NIH, Natl. Inst. Environmental Health Sciences

0271 EFFECTS OF 915 MHz MICROWAVE RADIATION IN RATS. Lovely, R.; Guy, A. (Univ. Washington, Sch. Medicine, Dept. Rehabilitation Surgery, 500 17th Ave., Seattle, WA 98122).

Wistar rats will be exposed to 915 MHz microwave radiation at a power density of 5 mW/cm², 8 hr/night for 3 mo. Changes in urinary ketosteroid levels, glutathione levels, and serum cholinesterase activity will be followed during exposure and through a 2-mo recovery period. Changes in behavioral response

to an attention vigilance task will also be studied. (10/77-9/78)

Supporting Agency:HEW, PHS, NIH, Natl. Inst. Environmental Health Sciences

0272 THE EFFECTS OF PRENATAL EXPOSURE TO 2450 MHz MICROWAVE RADIATION IN RATS. Lovely, R.; Guy, A. (Univ. Washington, Sch. Medicine, Dept. Rehabilitation Medicine, 500 17th Ave., Seattle, WA 98122).

Wistar rats will be exposed in utero to 2,450 MHz microwave radiation at a power density of 5 mW/cm². Behavior of the rats will be observed from birth through maturation. All animals will be sacrificed for pathologic examinations. (10/77-9/78)

Supporting Agency:HEW, PHS, NIH, Natl. Inst. Environmental Health Sciences

0273 TERATOLOGICAL STUDY OF 2450 MHz MICROWAVE EXPOSURE IN MICE. McRee, D. I.; Nawrot, P. (Environmental Biophysics Lab., Natl. Inst. Environmental Health Sciences, U. S. Dept. HEW, Durham, NC 27709).

Separate groups of pregnant CD1 mice were exposed to 2,450 MHz microwave radiation at power densities of 5 and 20 mW/cm², 8 hr/day for 17 days. Animals were sacrificed prior to parturition, and fetuses were examined for developmental effects of the radiation. A third group of pregnant CD1 mice are presently being exposed to 2,450 MHz microwave radiation at a power density of 30 mW/cm². (10/77-9/78)

Supporting Agency:HEW, PHS, NIH, Natl. Inst. Environmental Health Sciences

0274 TERATOLOGICAL EFFECTS OF MICROWAVE RADIATION IN RATS. Berman, E. (EPA, Experimental Biology Div., Durham, NC 27711).

Sprague-Dawley rats will be exposed to 100 MHz microwave radiation for 4 hr/day during the entire period of organogenesis in a Crawford cell device. Following exposure, animals will be sacrificed and fetuses examined for morphologic effects of the radiation. (10/77-9/78)

Supporting Agency:EPA

0275 VESTIBULO-COCHLEAR EFFECTS OF UHF-MICROWAVE RADIATION. Lebovitz, R. M.; Seaman, R. L. (Univ. Texas, Sch. Medicine, Dept. Physiology, 5323 Harry Hines Blvd., Dallas, TX 75230).

This research will document the effects of microwave radiation (MWR) on the nervous system by examining single unit discharge in sensory systems that are responsive to continuous wave or pulse-modulated MWR. Previous work confirmed that single units in the vestibular pathway and single units in the auditory pathway show an acute response to continu-

ous wave and pulse MWR, respectively. This project will derive a more complete quantitative understanding of these interactions, investigate the underlying physical mechanisms, and evaluate the general biologic significance of these MWR effects in cats. Similar studies using laboratory primates will then follow. The response of single vestibular units and of single auditory units to appropriate physiologic stimuli will be recorded via glass micropipette located in the eighth nerve and in brain stem vestibular and cochlear nuclei. Once functionally identified, the subsequent response of the units of MWR (915 and 2,450 MHz) applied to the head will be noted. For vestibular units, the emphasis will be on their response to physiologic angular acceleration of the head as compared with their response to exposure to near field continuous wave MWR. For auditory unit the emphasis will be on their response to physiologic acoustic stimuli (tone bursts and clicks) as compared with their response to pulse-modulated MWR. The capability of pulsed MWR to mask acoustic stimuli will also be examined. Calibration of the MWR dose will be in terms of regional absorbed energy density. Recording sites will be marked and verified by histologic examination. These data will be applied to the analysis of the biologic hazards of pulsed MWR and of the biomedical utility of MWR interaction with the central nervous system. (1/78-12/78)

Supporting Agency:HEW, PHS, NIH, Natl. Inst. Environmental Health Sciences

0276 NAVY ENVIRONMENT: EXPERIMENTAL DEVELOPMENT OF SIMULATED BIOTISSUES. Cheung, A. (Univ. Maryland, Graduate Sch., College Park, MD 20740).

An attempt will be made to develop a systematic procedure to simulate any biologic tissue electrically at any given temperature for microwave dosimetry studies. Frequency sweep measurement of dielectric properties of various mixtures of simulated muscle, bone, and fat will be made at several temperatures and at frequencies from 1 to 18 GHz. Dependence, relative dielectric constant, and conductivity as a function of frequency, temperature, and composition will be determined as well as complex dielectric properties. Compositions and physical properties will be tabulated in handbook form for different temperatures and frequencies and other physical properties. (10/77-9/78)

Supporting Agency:U.S. Dep. Def., Navy

0277 NAVY ENVIRONMENT: BIOMEDICAL EFFECTS OF RADIO FREQUENCY RADIATION. Lin, J. C.; Kraus, G. E. (Wayne State Univ., Sch. Engineering, Dept. Electrical Engineering, 5950 Cass Ave., Detroit, MI 48202).

This research program will be part of the Navy effort to determine the potential for human hazard in the frequency range of 30-300 MHz. This study will investigate the effect of radio frequency rad-

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iation on the growth, reproduction, and pathology of mice. The mice will be exposed, both acutely and chronically, in a parallel strip transmission chamber where plane wave fields with variable E/H ratios can be produced. Temperature distribution and patterns will be established and phantom models of both mice and man will be used to establish correlations. (10/77-9/78)

Supporting Agency:U.S. Dep. Def., Navy

0278 **THEORETICAL AND EXPERIMENTAL BIOMAGNETISM.**
Farrell, D. E. (Case Western Reserve
Univ., Graduate Sch., Dept. Physics, 2040 Adelbert
Rd., Cleveland, OH 44106).

The characteristics of the magnetic signal from the His bundle in the human heart will be investigated theoretically and experimentally. A simple source model will be used to compute the external electric and magnetic fields and to investigate the effects of torso geometry and internal inhomogeneities on the properties of the signal. For the experimental work, a SQUID first-order gradiometer system will be employed having a lower intrinsic noise level than any magnetic detector in current operation. The major goal of this research is to provide a clear test of the existing theoretic framework of biomagnetism for a well-defined system of practical interest. Additionally, a relatively unknown regime for magnetic detection will be explored experimentally, and the practical limits on such measurements established. (12/77-11/78)

Supporting Agency:NSF

0279 **EXTERNAL CARDIAC STIMULATION WITH MICROWAVE RADIATION.** Zoll, P. M.; Frank, H. A.; Belgard, A. H.; Zoll, R. H. (Beth Israel Hosp., 330 Brookline Ave., Boston, MA 02215).

Researchers will develop the apparatus and techniques by which microwave thermal energy, applied externally over the precordium, may be transmitted through the chest wall to warm atrial or ventricular pacemaker cells in selected areas of the heart to arouse, accelerate, and maintain intrinsic rhythms at clinically useful rates and time intervals. A microwave generator and matched applicator will be developed using solid-state microwave techniques, computer simulations, optimization procedures, and modern fabrication technologies to allow control of the depth of penetration, volume of tissue irradiated, and temperature change. The distribution, degree, and temporal course of heating of the target areas of the heart and of intervening tissues will be determined in normal anesthetized dogs by appropriate placement of thermistor probes. In dogs with surgically induced atrioventricular block the changes in atrial and ventricular rhythmicity will be studied. In particular, acceleration of the normal sino-atrial node and of the dominant idioventricular pacemaker, and the arousal, acceleration, and maintenance of ectopic atrial and ventricular pacemaker will be

examined. Thermal effects on cardiac metabolism and hemodynamics will also be observed. Techniques of temporary control of cardiac rhythm to be developed will be quick, effective, entirely safe and painless, and completely noninvasive. Such techniques may supplement and possibly supplant present-day methods involving external cardiac pacemakers and intravenous drugs. (12/77-11/78)

Supporting Agency:HEW, PHS, NIH, Natl. Heart Lung & Blood Inst.

0280 **RADIOFREQUENCY RADIATION INTERFERENCE (RFI) OF MEDICAL PROSTATIC DEVICES.** Mitchell, J. C.; Hardy, K. A. (U.S. Air Force, Sch. Aerospace Medicine, Brooks Air Force Base, San Antonio, TX 78235).

A biomedical data base on the interaction of Air Force radio frequency (RF) radiation emitters and medical prosthetic devices will be established, and a state-of-the-art technology watch on cardiac pacemaker interference will be maintained. Manufacturers' progress in developing pacemakers to operate properly in pulsed RF fields of 200 root mean square V/m will be assessed, and the data will be applied to operational situations in accordance with Air Force regulation (AFR) 161-42. New state-of-technology pacemakers will be accepted on loan from manufacturers and evaluated under a variety of RF emission sources in the USAFSAM laboratory. Sources will include radio frequencies between 50-500 MHz. Field tests will also be conducted using a high frequency transmission system. Additional field tests will be conducted in support of specific operational problems as provided by AFR 161-42. (10/77-9/78)

Supporting Agency:U.S. Dep. Def., Air Force

0281 **EFFECTS OF MICROWAVES ON IMMUNE DEFENSE MECHANISMS IN MICE.** Huang, A. (Dept. Internal Medicine, Duke Univ. Sch. Medicine, Box 3711, Durham, NC 27706).

BALB/c mice are being exposed to a microwave frequency of 2,450 MHz at a power density of 15 mW/cm², 15 min/day for 3 wk. Following exposure, the mice are sacrificed and immunocompetent cells are studied for morphologic and biochemical changes, such as, lymphoblastoid transformation, mitotic figures and DNA, RNA and protein synthesis. (10/77-9/78)

Supporting Agency:EPA

0282 **BIOLOGICAL EFFECTS OF AF RF TRANSMITTER FIELDS.** Frazer, J. W.; Barnes, C. (U.S. Air Force, Sch. Aerospace Medicine, Brooks Air Force Base, San Antonio, TX 78235).

The setting of safety standards for Air Force (AF) personnel exposed to electromagnetic radiation (EMR) must rest on a foundation of known bioeffects. This effort will investigate radio frequency (RF)

field effects on biophysical model systems. The information gathered will allow the adjustment of exposure criteria for AF personnel working in unique RF radiation environments. Field modulation effects, including pulsed fields, on a variety of central nervous system (CNS) ionic and chemical distributions will be examined. The effects of EMR fields on solvent transport processes in tissue and polarization processes in macromolecules will also be investigated. Alterations in the trace metal content in various areas of the rat CNS will be related with frequency, power density, and thermal stress, and these findings will be extrapolated to an expected effect on AF personnel operating in EMR environments. (10/77-9/78)

Supporting Agency:U.S. Dep. Def., Air Force

0283 MICROWAVE CATARACTOGENESIS. Oosta, G. M.; Mathewson, N. S. (U.S. Dept. Defense, Armed Forces Radiobiology Res. Inst., Bethesda, MD 20014).

The effect of microwave radiation on proteins in rabbit lens will be determined as well as the relationship between expected microwave-induced alterations of lenticular proteins and duration of exposure at constant power density. Test animals will be exposed to subcataractogenic and cataractogenic levels of 2.45 GHz radiation. Possible conversion of soluble lens proteins to an insoluble form during microwave-induced cataractogenesis will be investigated. Quantity of soluble protein will be determined after extraction of all soluble lens proteins in a suitable solvent. Variables in extraction procedure will be studied to determine if soluble protein is converted to insoluble protein by the extraction procedure itself. After suitable extraction of lens proteins, quantity of alpha, beta, and gamma crystallins will be measured to determine possible alterations in protein concentration in rabbit lens as a result of microwave insult. Each crystallin will be analyzed to determine shifts in subunit composition and changes in chemical/physical properties attributable to microwave damage. (10/77-9/78)

Supporting Agency:U.S. Dep. Def., Def. Nuclear Agency

0284 PERSONNEL TECHNOLOGY: DETERMINATION & IDENTIFICATION OF EVOKED MAGNETIC RESPONSE OF THE HUMAN BRAIN ASSOCIATED WITH SENSORY STIMULATION. Kaufman, L.; Williamson, S. J. (New York Univ., Sch. Arts & Sciences, Dept. Psychology, 421 1st Ave., New York, NY 10012).

The investigators will attempt to relate the temporal and spatial features of the magnetic field external to the scalp to sensory stimulation and the internal state of the subject. Such information should provide a better understanding of neurologic relationships and lead to improved stimulus presentation for Naval equipment displays. Such data should also allow more precise identification of brain neurologic problem areas in Naval personnel. Proposed

experiments will use a modified reaction time paradigm to visually presented stimuli (gratings) in which spatial and temporal frequency are varied while luminance and adaptation level are held constant in an attempt to differentiate the sensory from the motor components. Other experiments will examine the effects of selective (divided) visual attention on the neuromagnetic response. (10/77-9/78)

Supporting Agency:U.S. Dep. Def., Navy

0285 NAVY ENVIRONMENT: THE NATURE OF ELECTROMAGNETIC FIELD INTERACTION WITH BIOLOGICAL SYSTEM FUNCTION. Frey, A. H. (Randomline, Inc., Huntingdon Valley, PA 19006).

Naval personnel are exposed in many relatively closed spaces to varying levels of electromagnetic radiation, which can affect individual performance. This work will investigate the effects of exposure to electromagnetic energy on neural activity and behavior. Research on the blood-brain barrier will be extended utilizing autoradiographic techniques to study events in the brain during exposure to electromagnetic energy. This should enable identification of the locus of action of the energy and the nature of changes that may occur in the brain. Thresholds will be sought as well as electromagnetic field effects using fluorescent dyes. (10/77-9/78)

Supporting Agency:U.S. Dep. Def., Navy

0286 COMMITTEE ON RADIO FREQUENCIES--SUPPORT OF COMMITTEE OPERATIONS. Dow, R. Y. (Natl. Acad. Sciences, 2101 Constitution Ave. N.W., Washington, DC 20037).

The Committee on Radio Frequencies (CORF) of the National Academy of Sciences and Engineering provides advice and recommendations to the NSF and other government agencies in the use of the radio spectrum for research purposes. The CORF has three subcommittees that deal with radio astronomy, biologic sciences, and atmospheric and space sciences, respectively. At present, the Committee is projecting the spectrum needs of U.S. researchers for the next 20 years. Findings will be presented to appropriate federal channels to formulate the U.S. position for the 1979 World Administrative Radio Conference. The Committee works via correspondence and periodic meetings of the main and subcommittees. The Executive Secretary at the National Academy of Science is the local contact and handles administrative matters for the Committee. (3/76-12/76)

Supporting Agency:NSF

0287 NAVY ENVIRONMENT: INVESTIGATION OF THE BIOLOGICAL EFFECTS OF PULSED ELECTROMAGNETIC FIELDS GENERATED BY NAVAL OPERATIONS. Cleary, S. F. (Dept. Biophysics Virginia Commonwealth Univ., Sch. Medicine, 1200 E. Broad St., Richmond, VA 23298).

CURRENT RESEARCH

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High frequency, high intensity electromagnetic pulse (EMP) fields can be produced by certain naval operations. This research is an attempt to determine if the instantaneous field strengths and pulse characteristics of EMP are capable of producing biologic alterations of interest to man. This will be a three-part study. The first will be a study of the effects of EMP fields on serum proteins, blood chemistry, and drug-induced (pentobarbital) sleeping time in the Dutch rabbit. The second phase of this work will be a study of EMP and microwave fields on an artificial biomembrane of known resistance, membrane potential, and dielectric breakdown potential. These membrane properties will be investigated as a function of the amplitude and pulse rate of an applied EMP field. The third study will examine the effects of low intensity electric field pulses on erythrocytes. (10/77-9/78)

Supporting Agency:U.S. Dep. Def., Navy

0288 BEHAVIORAL CHARACTERISTICS OF MONKEYS AND RATS IRRADIATED WITH MICROWAVES. Delorge, J. O.; Grissett, J. D. (U.S. Navy, Biomedical Div., Pensacola, FL 32512).

The effects of low power density microwave radiation on monkeys and rats will be investigated by measuring their ongoing operant behavior. Rhesus monkeys, squirrel monkeys, and rats trained on various operant tasks will be exposed for prolonged durations to microwave radiation at low power levels, pulsed at selected frequencies. The animals, while working, will be exposed to vertically or horizontally polarized radiation at 2.4 and 6 GHz to demonstrate differential effects of polarization and frequency. The exposures will occur in essentially non-reflective restraint devices. In addition, the animals, chosen for size differences, will perform on similar tasks to permit a comparative study of animal size and microwave parameters utilizing behavior as the dependent variable. (10/77-9/78)

Supporting Agency:U.S. Dep. Def., Navy

0289 BIOLOGICAL EFFECTS OF LOCALIZED E- AND H- FIELDS IN THE STANDING MICROWAVE FIELD. Olsen, R. G.; Grissett, J. D. (U.S. Navy, Biomedical Div., Pensacola, FL 32512).

The effects of the application of individual microwave field quantities on small biologic systems will be studied. These field quantities are the electric field intensity (E-field) and the magnetic flux density (H-field). Both fields exist in a traveling plane wave; however, when a plane wave is reflected from a conducting surface, a standing wave pattern is created in which one field quantity predominates. Since these standing waves are found on board ship because of reflections from bulkheads, other conducting structures, and equipment, it is important to determine whether specific biologic effects result from exposure to one field quantity or the other. A 4.0 GHz planar standing wave pattern,

generated by plane wave reflection from a metal plate at normal incidence, will be used to irradiate 1- or 2-day old mealworm pupae. The pupae will be placed in regions of the standing wave that contain predominantly one field component or the other. The input power will be adjusted to produce approximately the same microwave dose rate in the pupae as has been used in former studies where irradiation has produced morphologic damage in the emergent adults. (10/77-9/78)

Supporting Agency:U.S. Dept. Def., Navy

0290 NAVY ENVIRONMENT: EFFECT OF RF AND MICROWAVE RADIATION ON NERVOUS SYSTEMS. Takashima, S.; Kritikos, H. N. (Univ. Pennsylvania, Sch. Electrical Engineering, 203 Logan Hall, Philadelphia, PA 19104).

An investigation of the potential hazards and mechanisms of radio frequency (RF) and microwave fields, of the type generated by naval operations, will be performed on nervous systems of animals. Rabbits will be chronically implanted on the dura mater of the cortex. Electroencephalographic (EEG) signals will be recorded and processed under varying experimental conditions. Parameters will include modulation (various), field strength, and carrier frequencies. An attempt will be made to cross-correlate signals from cells in different parts of the brain, both during and after microwave and RF exposure. (10/77-9/78)

Supporting Agency:U.S. Dep. Def., Navy

0291 BIOCHEMICAL EFFECTS OF MICROWAVE RADIATION. Grissett, J. D.; Lotz, W. G. (U.S. Navy, Biomedical Div., Pensacola, FL 32512).

This investigation will provide quantitative measurements of neuroendocrine stress induced by microwave radiation and assess the physiologic significance of the total stress response. Neuroendocrine parameters will be measured on Rhesus monkeys for both acute and chronic exposure. For acute experiments the animals will be exposed for 8 hr during a 24-hr period. Blood samples will be drawn at 2-hr intervals. When the neuroendocrine response is determined for short exposure at high power levels, the frequency and pulse parameters will be used at moderate power levels for chronic exposure to determine the total physiologic significance of responses at a particular set of field conditions. (10/77-9/78)

Supporting Agency:U.S. Dep. Def., Navy

0292 MEASUREMENT OF RFR POWER DISTRIBUTION. Guy, A. W.; Lovely, R. H. (Univ. Washington, Sch. Medicine, 500 17th Ave., Seattle, WA 98122).

High level national concern over the adequacy of existing radio frequency safety standards has highlighted the need to define experimental exposure

fields accurately, insure intercomparability of power deposition and mechanism of injury studies, and validate theoretic predictions with measured distributions in experimental animals. This effort will investigate ground plane and position effects on power absorption in several man models at the University of Washington and at USAFSAM/RA. Investigators will intercompare field measurement techniques used at the University of Washington and those used at USAFSAM and compare the theoretic and measured distributions in experimental animals exposed in both facilities. In addition, an exposure system will be designed and constructed for cell or tissue cultures when fields within culture can be exactly specified. Investigators hope to demonstrate the utility of the culture system by exposing freshly isolated primate lymphocytes with and without simulating antigens. University of Washington personnel are to bring thermographic equipment and field measurement devices to USAFSAM to compare their measurements with those at USAFSAM. Killed animal models and physical models are to be examined after exposure to a variety of frequencies generated by the high frequency band coax near field synthesizer and the University of Washington resonant cavity at USAFSAM and at the University of Washington. Fields generated by the multiple frequency exposure apparatus will also be provisionally examined at SAM. An exposure cell is to be constructed from readily available materials, and its utility demonstrated by exposure of freshly isolated lymphocytes to fields calculated for an equivalent field in man models exposed to a variety of field geometries. (10/77-9/78)

Supporting Agency:U.S. Dep. Def., Air Force

0293 MICROWAVE-INDUCED DAMAGE IN THE MAMMALIAN BRAIN. Catravas, G. N. (U.S. Dept. Defense, Armed Forces Radiobiological Res. Inst., Bethesda, MD 20014).

Changes in levels of neurotransmitters and activities of enzymes involved in neurotransmitter metabolism in the central nervous system of microwave-irradiated animals will be determined. East European studies have indicated that microwave irradiation at low, nonthermal levels results in a number of neurologic and behavioral effects in animals and humans. To substantiate Russian data, a systematic study will be conducted to determine if and to what extent neurochemical mechanisms in mammalian brain are affected by exposure to low level microwave radiation. Groups of rats will be exposed to continuous low-level microwave radiation of 2,450 MHz and approximately 10 mW/cm². At various postirradiated time intervals levels of acetylcholine, norepinephrine, dopamine, and serotonin will be determined in discrete brain areas of experimental animals and sham-irradiated controls. Radiation-induced changes in activity of brain enzymes, choline acetyltransferase, acetylcholinesterase, tyrosine hydroxylase, cryptophan hydroxylase and monoamine oxidase, which are involved in neurotransmitter metabolism, will also be determined. In another series of experiments the effect of microwave radiation on adenylycyclase-cyclic adenosine

monophosphate and prostaglandin system will be determined. (10/77-9/78)

Supporting Agency:U.S. Dep. Def., Def. Nuclear Agency

0294 RADIOFREQUENCY ELECTROMAGNETIC ENVIRONMENT SIMULATION AND MEASUREMENT. Allen, S. J.; Hurt, W. (U.S. Air Force, Sch. Aerospace Medicine, Brooks Air Force Base, San Antonio, TX 78235).

Equipment and methodology will be developed to perform the experiments necessary to define radio frequency (RF) energy transfer to animals and man. The results of these experiments will provide the basis for modifying the personnel exposure criteria for Air Force (AF) RF operations. Instrumentation will be developed to monitor incident fields and absorbed power for biologic systems exposed to RF fields in the range of operational AF systems, namely, 10 MHz to 10 GHz. Present power absorption techniques are usable from 10 to 50 MHz. Methodology to be developed will measure power absorptions in the 50 MHz to 10 GHz frequency range. Modelling of animals will continue until a suitable model is found that will be used to perform the theoretic analysis necessary to predict power absorption in the relevant frequency range. (10/77-9/78)

Supporting Agency:U.S. Dep. Def., Air Force

0295 PHYSICAL SCIENCE COLLABORATIVE RESEARCH. Atkinson, E. R. (Div. Cancer Treatment, Natl. Cancer Inst., HEW, Bethesda, MD 20014).

Physical science collaboration is being conducted in automated tissue culture colony counting, millimeter wave spectroscopy of tumor cells, whole body hyperthermia patient treatment, whole body hyperthermia animal studies, toxicity of chemotherapeutic agents at elevated temperatures, non-thermal effects of microwaves, precision measurement of size of biologic objects, mass spectroscopy of biopolymers and unnatural isotopes, nuclear magnetic resonance of membrane specific proteins, human thermoregulation, receptor site tertiary structure by electron spin resonance, dielectric properties of normal and tumor tissues, pion production at low energies in the laboratory frame, tissue sensitizers for ionizing radiation, microwave imaging techniques, ultrasonic temperature measurement, liquid crystal effects in biologic materials, optical and viscometric techniques for temperature measurement, and actin and myosin mechanics. (10/76-9/77)

Supporting Agency:HEW, PHS, NIH, NCI

0296 EFFECTS OF 2450 MHZ MICROWAVES ON THE EMBRYONIC DEVELOPMENT OF JAPANESE QUAIL. McRee, D. I.; Hamrick, P. E.; Thaxton, J. P.; Parkhurst, C. R. (HEW, Natl. Inst. Environmental Health Science, Environmental Biophysics Lab., Durham, NC 27709).

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Juvenile quail were challenged at 5 weeks of age with sheep red blood cells (SRBC), and the levels of anti-SRBC antibodies were determined. The levels of specific antibodies, determined 4 days after antigen challenges, were the same magnitude for both the exposed and control quail. Following this assessment of humoral immunity, the quail were sacrificed, and the bursa of Fabricius and spleen were removed, and exposed and control birds compared. No significant alterations were seen in the microwave exposed group. Other groups of eggs were exposed to a power density of 5 mW/cm² for the first 12 days of development. After hatching, the quail were allowed to mature and mate. Eggs for the matings were hatched in a standard incubator. After collecting over 1,000 eggs in each mating group, it was found that the exposed males when mated with either the control or exposed females produced a 10% decrease in fertility. The exposed females when mated with the control males resulted in the same fertility rates as mating the control females with control males. Mating behavior studies were performed. No differences in the number of matings or mating attempts were observed between control and exposed quail. (10/76-9/77)

Supporting Agency:HEW, PHS, NIH, Natl. Inst.
Environmental Health Sci.

0297 BEHAVIORAL AND PHYSIOLOGICAL EFFECTS OF
MICROWAVE EXPOSURE IN RATS. Lovely, R.;
Guy, A. (Univ. Washington, Sch. Medicine, Dept.
Rehabilitation Medicine, 500 17th Ave., Seattle,
WA 98122).

Wistar rats were exposed to a microwave frequency of 915 MHz at power densities of 2.5 mW/cm², 10 hr/night for 3 mo. The radiation was circularly polarized by a wave guide to provide constant dosing for whole body exposure. During exposure, serum chemistry and behavioral parameters including eating, free operant analysis, conditioning situations, and avoidance tasks were studied. (10/77-9/78)

Supporting Agency:U.S. Dep. Def., Navy

0298 RADIOFREQUENCY RADIATION EFFECTS ON BIO-CHEMICAL SYSTEMS IN THE CENTRAL NERVOUS SYSTEM. Merritt, J. H.; Frazer, J. W. (U.S. Air Force, Sch. Aerospace Medicine, Brooks Air Force Base, San Antonio, TX 78235).

The Department of Defense Triservice Electromagnetic Radiation (EMR) Bioeffects Research Program describes the central nervous system (CNS) as the "singularly most important area where there is evidence that EMR interacts with biological systems." The objective of this effort is to quantitate the radio frequency (RF) EMR effects on biochemical events subserving nerve transmission in the CNS. The information obtained will be applied to establish more appropriate safety standards for personnel working in close proximity to Air Force RF emitters. The effects of RF radiation on the CNS, specifically on

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a specialized function of the neuron, namely synaptic transmission, will be studied. This effort will attempt to quantify changes produced by RF energy in these chemical switching systems, determine thresholds for frequency and power density, and interpret these changes in terms of the expected effect on man in Air Force operational environments. (10/77-9/78)

Supporting Agency:U.S. Dep. Def., Air Force

0299 BEHAVIORAL AND PHYSIOLOGICAL EFFECTS OF
MICROWAVE RADIATION IN MONKEYS. McAfee,
R.; Gordon, R.; Longacre, A.; May, J. (Louisiana
State Univ. Systems, Sch. Engineering, 1542 Tulane
Ave., New Orleans, LA 70122).

Rhesus monkeys, *Macaca mulatta*, are being studied for behavioral and physiologic effects of 930 MHz microwave radiation. The animals are being irradiated 4 days/wk for 52 wk. The monkeys are maintained in family groups in outdoor cages where individuals can enter an irradiation chamber and depress a drinking tube that delivers apple juice and activates a microwave generator exposing the animals' faces and eyes to radiation power densities between 150 and 495 mW/cm². Follow-up will last 2 additional yr. Animals will be examined for evidence of ocular damage and will be observed for behavioral aberrations and reproductive capability. (10/77-9/78)

Supporting Agency:U.S. Veterans Admin.

0300 COMPARISON OF THEORETICAL AND EXPERIMENTAL
ABSORPTION OF RADIOFREQUENCY POWER.
Johnson, C. C.; Barber, P. (Utah Higher Education
System, Sch. Engineering, Dept. Electrical Engineering,
1400 E. 2nd St., Salt Lake City, UT 84112).

Methods and data are needed to extrapolate (via appropriate scaling factors) animal data to man to establish more realistic personnel safety electromagnetic radiation (EMR) exposure guidelines for Air Force Operations. The specific objectives of this study are (1) to define adequate models, (2) to extend theoretic radio frequency (RF) power absorption data to assess consequences of human exposure to 10 KHz to 1.5 GHz RF radiation fields, and (3) to develop methods, accounting for size and orientation effects, to extrapolate animal exposures to equivalent human exposures. Twenty phantoms will be constructed to simulate 3.5 kg monkeys. Absorbed power will be calculated utilizing this monkey model for exposures in free space, near field, and on a ground plane. Experiments will be conducted to measure power absorbed in the phantom and in actual monkeys for six exposure orientations. The best model for man, monkey, rat and mouse will be developed, and calculations will be performed to determine power density to which these animals should be exposed to produce the same average absorbed power as man when exposed to 10 mW/cm² at the same frequency. The exposure frequency for animals subjected to the

same power density as man to accomplish equivalent average power absorption will also be calculated. These data will be used to compile a handbook (Researcher's Guide) for use in selecting appropriate exposure parameters (frequency and power density) for animal studies to simulate bioeffects in man. Power absorption calculations for man and animals will be extended to 1.5 GHz using wave solution, numeric techniques, or other applicable methods. (10/77-9/78)

Supporting Agency:U.S. Dept. Def., Air Force

0301 MECHANISMS OF NEUROENDOCRINE RESPONSE TO ELECTROMAGNETIC RADIANT ENERGY. Michaelson, S. M.; Lu, S. (Univ. Rochester, Sch. Medicine & Dentistry, Dept. Radiation Biology & Biophysics, 601 Elmwood Ave., Rochester, NY 14642).

Studies are performed in the rat and dog to relate the sequential changes in hypothalamic and pituitary function to alterations in body metabolism or homeokinetic perturbations as a result of exposure to various regimens of X-rays, microwaves, or combinations of these two electromagnetic energies during the perinatal as well as adult periods of life. Radioimmunoassay techniques and competitive protein-binding analysis are utilized to measure fluctuations in pituitary, thyroid, and adrenal hormones; to study homeostasis, impairment of physiologic capacity, and functional integrity of the neuroendocrine system; and to assess pathophysiological sequelae from exposure to electromagnetic radiant energies. Dogs subjected to X-irradiation (100 or 1,000 R) to the head or 1,000 R to the thyroid show altered integration of the hypothalamic-hypophyseal thyroid and adrenal axes with compensatory thyroid-stimulating hormone, T₄, catecholamine, and glucocorticoid response to cold. Alteration of the thyrostat set-point is seen in rats 8 wk after 400-1,300 R head/neck X-irradiation; thyroid and pituitary neoplasms appear in 1-2 yr. Microwave exposure of adult rats induces corticosterone increase in relation to increased body temperature; in-utero exposure (40 mW/cm²) results in earlier maturation. (10/76-9/77)

Supporting Agency:ERDA

0302 NAVY ENVIRONMENT: EFFECTS OF MICROWAVES ON MATURATION IN THE RAT. Michaelson, S. (Univ. Rochester, Sch. Medicine & Dentistry, Dept. Radiation Biology & Biophysics, 601 Elmwood Ave., Rochester, NY 14642).

Research to date has shown that microwaves affect the growth and development of the rat fetus when the exposure is properly placed during the gestational period. Brain growth appears to be most affected. This research will attempt to study how subsequent neonatal development and maturation of temperature regulation, which involves neural, hormonal and mutational facets, are modified by the in utero exposures. The development of the brain and ontogeny of temperature will be studied by ex-

posing individual rats (previously exposed in utero) of specific ages to a mild cold stress 25-30 C and measuring metabolism (O₂ consumption) and peripheral venous vasoconstriction. If a deficit appears, substrate, hormonal, or neural factors that may be responsible will be examined. Some animals will be decapitated for gross and microscopic examination of the brain. During the second yr, power density/time relationships will be developed on the basis of body surface. (7/77-9/78)

Supporting Agency:U.S. Dep. Def., Navy

0303 REFLECTION AND DIFFRACTION ASPECTS OF BIOLOGICAL MICROWAVE DOSIMETRY. Olsen, R. G.; Grissett, J. D. (U.S. Navy, Biomedical Div., Pensacola, FL 32412).

The microwave energy absorbed by a reasonably realistic up-right human model of man-size dimensions, given an incident horizontal microwave beam, will be experimentally determined. This determination can allow a more accurate estimation of the microwave energy absorbed by naval personnel and can provide a basis for further studies of microwave absorption in man in other postdural and/or beam configurations. The ultimate aim of this investigation is to elucidate the physical parameters (beam polarization, body posture, ground plan orientation) that cause the largest deposition and/or concentration of microwave energy in the man-size model for a given frequency and field intensity. An electric energy density meter will be used to measure both the magnitude and direction of the vector electric field intensity in the region around the illuminated phantom model. A frequency of 1.0 GHz will be initially used to extend the results of previous experiments. Emphasis will be on the economic acquisition of a three-dimensional distribution of vector E-field values representative of a closed surface completely surrounding the man-size model. The phantom will consist of a pliable, putty-like substance with gross microwave absorption properties adjusted to those of mammalian tissue. (10/77-9/78)

Supporting Agency:U.S. Dep. Def., Navy

0304 NAVY ENVIRONMENT: QUANTITATION OF MICROWAVE RADIATION EFFECTS ON THE HEAD AND EYES OF RABBITS, PRIMATES AND MAN. Kramar, P. O.; Emery, A. (Dept. Rehabilitation Medicine, Univ. Washington, Sch. Medicine, 500 17th Ave., Seattle, WA 98122).

Exposure to microwave radiation can cause opacity and damage in the eye. The exact conditions under which these effects occur are yet to be established; consequently, there is a great deal of controversy concerning the safe level of human exposure to microwave radiation. The increased use of high power microwave equipment by the Navy and other armed services, as well as the general population, demands well-planned and expertly executed theoretic and experimental investigations. Rabbits will be ex-

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posed to 2,450 MHz microwaves at above threshold power levels, but at subthreshold time levels. Additional animals will be exposed to 300 mW/cm² incident power levels and subthreshold time periods, but the intervals between exposures will be varied from 1 to 5 days. Retrolental temperatures will be measured in some animals to determine if repeated subthreshold exposures alter the temperature-regulating mechanism of the eye. A fluorescein dye will be used to determine the effect of the microwaves on the blood flow to the eye. A recently developed heat source will be used to determine if merely heating the eye in a pattern similar to microwaves and up to the level known to cause cataracts will result in the formation of cataracts. (10/77-9/78)

Supporting Agency: U.S. Dep. Def., Navy

0305 **LABORATORY AND FIELD EVALUATIONS OF HEAT ENERGY TO CONTROL STORED-PRODUCT INSECTS.** Kirkpatrick, R. L. (U.S. Dept. Agriculture, Stored Products Insects Res. & Development Lab., 3401 Edwin Ave., Savannah, GA 31405).

To control stored-product insects infesting grain or other stored commodities, practical techniques will be developed, and these methods will be adapted for field evaluations using temperature, including infrared and microwave radiation. Data obtained from these laboratory and field tests will be used to develop a practical and inexpensive commercial unit to control stored-product insects. The laboratory tests will determine the repellancy, attractancy, effect on life history, behavioral responses, and dosage-mortality relationship of stored-product insects exposed to infrared, microwave radiation, and other types of heat energy. Exploratory tests have shown that recirculation of hot, dry air within 100-bu painted (black) metal bins can increase the temperature of wheat to prevent insect infestation if the overhead air space reaches 33 C or more. Thermo electronic devices were used during laboratory tests to increase the temperature of wheat to 36 C thereby reducing the number of rice weevils emerging from the treated wheat. During heat sensitivity studies, complete control of immature rice weevils in the egg and larval stages was obtained at 35 C. A 66% reduction was observed in mature larval and pupal stages, but no F(1) emergence was observed when these adults were allowed to oviposit. (10/77-9/78)

Supporting Agency: U.S. Dep. Agriculture

0306 **TUMOR RADIOTHERAPY--EFFECTS OF ULTRASOUND AND HEAT.** Hahn, G. M.; Marmor, J. B.; Li, G. C.; Fajardo, L. (Dept. Radiology, Stanford Univ., Sch. Medicine, Palo Alto, CA 94305).

The interaction of X-irradiation and chemotherapy with hyperthermia generated by ultrasound and microwaves in affecting tumor cures in laboratory animals will be investigated. Specifically, the effects of ultrasound and microwaves in cells will be

examined in vitro and in vivo at temperatures above 37 C. Combined treatments of X-irradiation (or chemotherapy) and hyperthermia will be quantitated in tissue culture systems and in experimental tumors. Both cell survival studies of EMT-6 tumors as well as tumor cure experiments with EMT-6 and other tumors will be performed. Combinations that prove promising will be examined for possible clinical applications. Equipment will be developed to carry out laboratory, and eventually, clinical studies. (12/77-2/78)

Supporting Agency: HEW, PHS, NIH, NCI

0307 **NAVY ENVIRONMENT: MECHANISMS OF MICROWAVE NEURAL INTERACTION.** Durney, C. H.; Lords, J. L. (Utah Higher Education System, Sch. Engineering, Dept. Electrical Engineering, 1400 E. 2nd St., Salt Lake City, UT 84112).

Recent increases in the use of microwave-emitting devices have caused growing concern about the health hazards resulting from exposure of personnel to microwave radiation. Though there is general agreement on the hazards resulting from tissue heating by high-level microwave irradiation, little is known about possible damage produced by exposure to low-power microwave radiation. This research will explore the mechanisms that cause responses at low levels in neural substrates. The research will be divided into two phases. First, the post-synaptic receptor sites will be studied, following isolation of receptor molecules from nerve remnants. Once isolated, the binding constants for Ca⁺⁺ and acetylcholine will be determined. Microwaves will then be used to determine effect on these constants. Second, synaptosomes, which are membranous structures that contain transmitter substances, will be studied to determine if microwaves enhance transmitter release. (10/77-9/78)

Supporting Agency: U.S. Dep. Def., Navy

0308 **NON-INVASIVE SENSING OF SUBCUTANEOUS TEMPERATURES.** Barrett, A. H.; Myers, P. C. (Massachusetts Inst. Technology, Sch. Science, 77 Massachusetts Ave., Cambridge, MA 02139).

Microwave thermography as a means of sensing subcutaneous temperatures in humans in a non-invasive manner will be evaluated. This harmless, painless technique sends no radiation into the body. Like infrared thermography, it measures the natural thermal radiation of body tissue. Unlike infrared thermography it senses tissue temperature at depths of several cm. Clinical trials on over 2,000 women for breast cancer detection have been conducted with 3.3-GHz instrument; 26 had biopsy-proven breast cancer. The resulting true positive and true negative rates exceeded 70% and were comparable to the infrared rates. The microwave and infrared techniques together detected 96% of the cancers. Similar studies will be conducted at 1.3 and 6.0 GHz to determine the best frequency for microwave detection of breast cancer. Clinical detection studies of other diseases will be

performed, including cerebrovascular disease, peripheral vascular disease, and tumors in internal organs. Improvements in antenna resolution, scanning and imaging, and thermal pattern analysis will be carried out. (9/77-8/78)

Supporting Agency:HEW, PHS, NIH, Natl. Inst.
General Medical Sci.

0309 ULTRASTRUCTURAL STUDIES OF MICROWAVE
CATARACTOGENESIS. Simon, D. R.; McKee,
A. E. (U.S. Navy Experimental Pathology Dept.,
Bethesda, MD 20014).

This research will investigate the earliest ultrastructural changes in mammalian lens following exposure to electromagnetic radiation, with special emphasis on defining the thermal effects. Microwave cataractogenesis will be studied using scanning and transmission electron microscopy and light microscopy. New Zealand red rabbits and owl monkeys will be used as experimental animals. Morphologic changes noted in the lens of animals exposed to cataractogenic levels of electromagnetic radiation will be compared with those from animals whose eyes will have been subjected to thermal insults of equal magnitude and duration but induced by the local application of a heating coil to the eye. (10/77-9/78)

Supporting Agency:U.S. Dep. Def., Navy

0310 BIOELECTRIC PHENOMENA CONTROLLING BONE
GROWTH. Bassett, C. A. (Columbia Univ.,
Sch. Medicine, 630 W. 168th St., New York, NY 10032).

Methods and mechanisms for the bioelectric control of cell function will be defined. The investigators will analyze potential dependent phenomena at cell surfaces involving interactions of charged species, such as, divalent cations and hormones. Inductively-coupled electromagnetic fields will be utilized to provide a variety of bioelectric perturbations. This approach will be assessed through *in vitro* studies of protein synthesis and ⁴⁵Ca release by osteogenic and chondrogenic cells and of dynamic Na ion transport in the toad bladder membrane, as well as by *in vivo* studies of fracture healing in a rat radial osteotomy model. Primary emphasis will be focused upon the elaboration of induced current pulse characteristics, which have biologic significance during bone formation and repair, e.g., shape, frequency content, amplitude spectrum, and repetition rate. Quantitative evaluations will be obtained via impedance; radioactive labelling; and radiographic, histologic, and mechanical testing techniques. (2/78-1/79)

Supporting Agency:HEW, PHS, NIH, NIAMDD

0311 EFFECT OF LOW-DOSE MICROWAVES ON THE IM-
MUNE RESPONSE OF MICE. Jedrzejczak, W.;
Sell, K. W. (U.S. Navy Medical Res. Inst., Bethesda,
MD 20014).

Effects of long-term low dose microwave exposure on the immune response of laboratory animals will be investigated. Mice will be irradiated with continuous or pulsed 2,450 MHz microwave radiation to a total single dose of 10 mW/g tissue one or more times during 1 or 2 wk. The same number (usually 9) will serve as a control. The bone marrow and peripheral blood picture of normal and microwave irradiated mice will be determined using routine methods. Spontaneous transformation of peripheral blood white cells in 6-hr cultures and spleen cells in 6-, 72-hr, and 5-day cultures will be evaluated by incorporation of tritiated thymidine, uridine, and leucine. Mitogen-induced transformation tests will be performed with spleen cells using phytohemagglutinin, concanavalin A, pokeweed Mitogen, lipopolysaccharide B of *Escherichia coli*, poly-L, and poly-C. Mixed lymphocyte culture tests also will be performed. Additionally, spleen cells from experimental animals will be evaluated for presence of surface markers: i.e., Fc receptor, complement receptor for quantitation of populations of B cells, and theta antigen for quantitation of T cells. (10/77-9/78)

Supporting Agency:U.S. Dep. Def., Navy

0312 INVESTIGATION OF THE FACTORS DETERMINING
MICROWAVE ABSORPTION IN NORMAL AND MALIGNANT
TISSUE. Grant, E. H.; Sheppard, R. J.; Szwarc-
nowski, S. A. (Univ. London, Campden Hill Rd.,
London W8 7AH, England).

Methods of optimizing the absorption of microwave energy by malignant tissue as a means of achieving differential heating will be devised. The project will involve both the development of methods of launching microwaves into a tumor and measuring the dielectric properties of normal and malignant tissue so that a frequency region can be identified in which microwave radiation is absorbed differentially by malignant cells at the expense of normal cells. An attempt will be made to propagate the microwaves with a probe or applicator consisting of a small diameter coaxial line mounted in a hypodermic needle. Matching experiments will be carried out using bolus material and measurements of standing wave ratio made for various sized applicators. The measurements of the electrical properties of normal and malignant tissue will be made using a time domain spectrometer (TDS) as well as by the more conventional frequency domain techniques. The aim is to determine the electrical permittivity and conductivity of solid tissue and cell suspensions over a frequency range of 1 MHz-100 GHz and to interpret the results in terms of the quantity and nature of the free water and water of hydration. If the current evidence that the water structure is different between normal and malignant tissue is substantiated, it should be possible to identify a frequency region where cancer cells absorb more radiowave or microwave energy than normal cells. A microwave probe has been devised and tested on tumor-bearing mice and good localization of heat in the tumor has been achieved. Owing to the very high conductivity of malignant tissue and

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solutions of cancer cells the first prerequisite was to devise and test TDS methods for the determination of the permittivity and conductivity of very lossy materials. This was achieved and solutions of adenosine triphosphate of conductivity around 1 Ohm/m were successfully measured. (10/77-9/78)

Supporting Agency:Cancer Res. Campaign, England

0313 A STUDY OF DENDRITIC SPINE MORPHOLOGY IN RAT BRAIN FOLLOWING CHRONIC EXPOSURE TO LOW INTENSITY MICROWAVE RADIATION. Hosszu, J. L.; McKee, A. E. (U.S. Navy, Engineering Support Dept., Bethesda, MD 20014).

Adult male rats and rabbits have been chronically exposed to pulsed microwaves (10 mW/cm², pulse repetition rate 1 kHz, .60 duty cycle, 2.7 GHz and 3.7 GHz, respectively) for 2 hr/day. Attempts will be made to assess morphologic effects described by the Soviets. Basilar and apical dendritic processes of pyramidal cells located in discrete areas of the sensory motor cortex will be examined at various depths for possible spine degeneration, in accordance with accepted rapid Golgi procedures. Classification as to type of dendritic process involved, area of tissue, and depth of observation will enable quantitative spine counting utilizing light microscopic techniques. Efforts will address the effects of altered electromagnetic radiation (EMR) parameters on dendritic spines, and cellular mechanisms known to modify dendritic proliferation. Further, because dendritic spine degeneration may show regional specificity, changes will be correlated with current knowledge of functional neuroanatomy. Spine degeneration studies will serve as a tool for understanding EMR effects at the systems level. (10/77-9/78)

Supporting Agency:U.S. Dep. Def., Navy

0314 THERMOGRAPHY AT MICROWAVE AND MILLIMETER WAVELENGTHS. Hendee, W. R.; Carson, P. L.; Cacak, R. K. (Univ. Colorado, Sch. Medicine, 4200 E. 9th Ave., Denver, CO 80220).

Thermographic instrumentation at 30 GHz (lower millimeter wavelength region) and at 1.5 GHz (lower microwave wavelength region) is being developed and evaluated physically preparatory to obtaining patient images. Because of the increased penetration depth of long wavelength thermography, data reflect thermal patterns from underlying tissues rather than the skin surface, as is the case with conventional thermography. Primary application of the proposed imaging techniques is to detect breast cancer, although other applications, such as, skeletal inflammation assessment also are being evaluated. In these applications, normal individuals and patients with known or suspected pathology will be included in clinical trials. (2/78-1/79)

Supporting Agency:HEW, PHS, NIH, NCI

0315 DEVELOPMENT OF ELECTROMAGNETIC RHEO-ANGIOGRAPHY. Kolin, A. (Univ. California, Sch. Medicine, 405 Hilgard Ave., Los Angeles, CA 90024).

See Current Research 0234 and 0323 for description of this research. (12/77-12/78)

Supporting Agency:HEW, PHS, NIH, Natl. Heart Lung & Blood Inst.

0316 NAVY ENVIRONMENT: EFFECTS OF MICROWAVE RADIATION ON CELLS IN TISSUE CULTURE. Chen, K. C.; Taylor, J. D. (Wayne State Univ., Sch. Liberal Arts, 4841 Cass Ave., Detroit, MI 48202).

See Current Research 0183 for description of this research. (10/77-9/78)

Supporting Agency:U.S. Dep. Def., Navy

0317 MICROWAVE EXPOSURE EFFECTS ON BEHAVIORAL ACTIONS OF PHARMACOLOGICAL AGENTS. Thomas, J. R. (U.S. Navy, Behavioral Sciences Dept., Bethesda, MD 20014).

See Current Research 0167 for description of this research. (10/77-9/78)

Supporting Agency:U.S. Dep. Def., Navy

0318 PROBLEM SOLVING IN RHESUS MONKEYS AS INFLUENCED BY MICROWAVES. Delorge, J. O.; Nelson, T. D. (U.S. Navy, Biomedical Div., Pensacola, FL 32512).

See Current Research 0170 for description of this research. (10/77-9/78)

Supporting Agency:U.S. Dep. Def., Navy

0319 LASER EYE MEASUREMENT AND EVALUATION SYSTEM. Bruckner, A. P.; Auth, D. C. (Univ. Washington, Sch. Engineering, 206 Guggenheim Hall, Seattle, WA 98105).

See Current Research 0175 for description of this research. (10/77-9/78)

Supporting Agency:U.S. Dep. Def., Air Force

0320 RF EFFECTS OF IMMUNE SYSTEMS. Liburdy, R. P.; Frazer, J. W. (U.S. Air Force, Sch. Aerospace Medicine, Brooks Air Force Base, San Antonio, TX 78235).

See Current Research 0168 for description of this research. (10/77-9/78)

Supporting Agency:U.S. Dep. Def., Air Force

0321 ASSESSMENT OF PERFORMANCE BASED ON FUNCTIONAL VISION. Devine, J. V. (Univ. Texas, Sch. Liberal Arts, El Paso, TX 79902).

See Current Research 0171 for description of this research. (10/77-9/78)

Supporting Agency:U.S. Dep. Def., Air Force

0322 ELECTRIC FIELD AND ELECTROMAGNETIC SENSOR CAPABILITIES OF MARINE ORGANISMS. Kalmijn, A. J.; Sheltema, R. (Woods Hole Oceanographic Inst., Main St., Woods Hole, MA 02543).

See Current Research 0206 for description of this research. (10/77-9/78)

Supporting Agency:U.S. Dep. Def., Navy

0323 DEVELOPMENT OF ELECTROMAGNETIC RHEOANGIOGRAPHY. Kolin, A.; MacAlpin, R. N.; Steckel, R. J.; Snow, H. O. (Univ. California, Sch. Medicine, 405 Hilgard Ave., Los Angeles, CA 90024).

See Current Research 0234 and 0315 for description of this research. (10/77-9/78)

Supporting Agency:HEW, PHS, NIH, Natl. Heart Lung & Blood Inst.

0324 EFFECTS OF MULTIPLE RF RADIATION EXPOSURES. Krupp, J. H. (U.S. Air Force, Sch. Aerospace Medicine, Brooks Air Force Base, San Antonio, TX 78235).

See Current Research 0235 for description of this research. (10/77-9/78)

Supporting Agency:U.S. Dep. Def., Air Force

0325 MICROWAVE EFFECTS. Tredici, T. J. (U.S. Air Force, Sch. Aerospace Medicine, Brooks Air Force Base, San Antonio, TX 78235).

See Current Research 0243 for description of this research. (10/77-9/78)

Supporting Agency:U.S. Dep. Def., Air Force

0326 ELECTROMAGNETIC BLOOD WARMING. Silva, J.; Bentley, R. K. (U.S. Navy, Systems Technology Dept., San Diego, CA 92151).

See Current Research 0186 for description of this research. (10/77-9/78)

Supporting Agency:U.S. Dep. Def., Navy

0327 EFFECTS OF MICROWAVE RADIATION ON THE NERVOUS SYSTEM. Lovely, R. H. (Univ. Washington Sch. Medicine, 500 17th Ave., Seattle, WA 98122).

See Current Research 0199 for description of this research. (11/77-6/78)

Supporting Agency:HEW, PHS, NIH, Natl. Inst. Environmental Health Sciences

0328 NAVY ENVIRONMENT: NEUROPHYSIOLOGICAL AND BEHAVIORAL EFFECTS DUE TO MICROWAVE FIELDS. Lovely, R. H.; Guy, A. W. (Univ. Washington, Sch. Medicine, 500 17th Ave., Seattle, WA 98122).

See Current Research 0174 for description of this research. (10/77-9/78)

Supporting Agency:U.S. Dep. Def., Navy

0329 LOW-LEVEL MICROWAVE RADIATION EFFECTS ON BEHAVIOR. Thomas, J. R.; Yeandle, S. (U.S. Navy, Behavioral Sciences Dept., Bethesda, MD 20014).

No descriptive information is available. (10/77-9/78)

Supporting Agency:U.S. Dep. Def., Navy

0330 EXPERIMENTAL RADIOTHERAPY FOR BRAIN TUMORS USING FOCUSED MICROWAVES. Samaras, G. M. (Univ. Maryland, Sch. Medicine, Dept. of Radiology, 1420 N. Charles St., Baltimore, MD 21201).

No descriptive information is available. (1/78-12/78)

Supporting Agency:American Cancer Society, Inc.

CURRENT LITERATURE

5443 CLINICAL EXPERIENCE WITH THE ADJUVANT TREATMENT OF PSEUDOARTHROSIS WITH ELECTROMAGNETIC POTENTIALS. (Ger.) Wiendl, H. J. (Unfallchir. Klinik, Allg. Krankenhaus, Untere Sandstrasse 32, 8600 Bamberg, W. Germany); Strigl, M. *Fortschr Med* 96(5): 231-236; 1978. (20 refs)

Twenty-two patients with pseudoarthrosis following fractures of the limbs, 5 patients who underwent osteotomy, and 1 patient with fresh fracture of the lower leg received postoperative adjuvant treatment with alternating electromagnetic fields according to the Kraus-Lechner method (300-500 mV, current density 1-2 A/mm² on electrode surface, 9-12 Oe, 20-25 Hz; 2x 120 min/day for 6-10 wk) in addition to osteosynthesis. All patients were in the age bracket 17-70 yr. Most patients were hospitalized during the treatment. One patient died of unrelated causes before evaluation was possible. Complete consolidation and recovery of the full load-bearing capacity was achieved in 2-5 mo in all patients with pseudoarthrosis, except for a 61-yr-old patient with pseudoarthrosis of the distal tibia following open comminuted fracture. Following osteotomy, the consolidation took 6-8 wk. The cure rate was higher than after exclusive osteosynthesis, because stable osteosynthesis was impossible in several cases, and less satisfactory results had been achieved in some pretreated patients without electromagnetic therapy. Subjective and objective side-effects and complications of the electromagnetic therapy were not seen.

5444 METABOLISM AND DISTRIBUTION IN THE ORGANS OF IRON, COPPER, MOLYBDENUM, MANGANESE AND NICKEL UNDER THE EFFECT OF ELECTROMAGNETIC FIELDS OF INDUSTRIAL AND SUPER-HIGH FREQUENCY. (Rus.) Gabovich, R. D. (Dept. General Hygiene, Kiev Medical Inst., Kiev, USSR); Mikhaliuk, I. A.; Koziarin, I. P.; Shutenko, O. I. *Gig Sanit* (7): 26-33; 1977. (10 refs)

The influence of electromagnetic fields on the excretion and distribution of copper, molybdenum, iron, and manganese was studied in male white Wistar rats. Exposure to 50 Hz field with potentials of 7, 12, and 15 kV/m, 30 min/day for 4 mo caused significant reduction of the copper concentration and an increase of the iron and molybdenum concentrations in the urine and feces. The copper content decreased significantly in the liver and increased in the whole body and in all other organs examined (kidneys, spleen, brain, myocardium, muscles, skin, bones, teeth, and blood). The molybdenum level decreased in the whole body and in all organs but the kidneys. The iron levels decreased in the whole body, in the liver, bone marrow, and blood. The manganese clearance and the manganese levels of the spleen, brain, myocardium and skin decreased in animals exposed to 7 and 12 kV/m and increased sharply in those exposed to 15 kV/m. The manganese level decreased in the bones and increased in the liver. Similar changes were observed in other groups exposed to 1-15 kV/m fields of 50 Hz for 2 hr/day over 4 mo. Other groups were exposed to high-frequency fields (2,370 MHz, 10-1,000

μW/cm², 8 hr/day for 4 mo). Exposure to such fields caused changes in the distribution of all metals, largely similar to changes seen in the above groups; the copper, manganese, and nickel levels usually decreased in the urine and feces and increased in most organs and in the whole body, while the iron clearance increased. The observed disturbances in the turnover of the metals are believed to play a certain role in the adaptive reactions of the body to the electromagnetic field.

5445 MECHANISMS OF THE EFFECT OF STATIONARY MAGNETIC FIELD ON INDUCED CARCINOGENESIS. (Rus.) Kogan, A. Kh. (Dept. Pathophysiology, I. M. Sechenov First Moscow Medical Inst., Moscow, USSR); Kulitskaia, V. I. *Patol Fiziol Eksp Ter* (2): 63-68; 1977. (38 refs)

The effect of permanent exposure to stationary magnetic field (SMF, 350 ± 30 Oe, gradient 75 Oe/cm) on sarcoma induction by 3,4-benzopyrene (BP) and polyvinyl chloride (PVC) was studied in outbred male rats. The magnetic field was applied by means of an electrode implanted under the skin of the back; carcinogens were applied to the implanted electrode. Non-magnetic electrodes with applied carcinogens were used on the controls. Carcinogenesis developed through standard stages, but the SMF increased the latency period from 3 mo 3 wk to 4 mo 2 wk in the group treated with BP ($p<0.01$) and from 12 mo to 13.5 mo ($p<0.05$) in the group treated with PVC, and accelerated the tumor growth [by increasing the tumor-to-body weight quotient from 2% to 5.2% ($p<0.05$) for BP and from 8.28% to 11.5% ($p<0.05$) for PVC]. SMF also increased the frequency of less differentiated (polymorphous-cell) sarcomas from 29.4% to 50% for BP and from 9.5% to 19.5% for PVC. Animals that survived the minimal latency period (2 mo 3 wk for BP and 7 mo for PVC) were 21/23 for BP, 21/25 for BP + SMF, 17/50 for PVC and 13/46 for PVC + SMF. SMF potentiated the peroxide free-radical oxidation of lipids during all precancerous stages of the tumor development. The findings indicate the synergistic effect of simultaneous SMF exposure on chemical carcinogenesis.

5446 THE REACTION OF THE IMMUNE SYSTEM TO THE COMBINED ACTION OF CHEMICAL AND PHYSICAL ENVIRONMENTAL FACTORS. (Rus.) Vinogradov, G. I. (A. N. Marzeev Kiev Scientific Res. Inst. General Communal Hygiene, Kiev, USSR). *Gig Sanit* (10): 28-31, 1977. (6 refs)

The effect of electromagnetic fields (5 and 50 μW/cm² super-high frequency, 7 hr/day for 1 mo) before or after exposure to formaldehyde (0.038 mg/m³, 7 hr/day for 1 mo) or carbon monoxide (CO: 3 mg/m³, 7 hr/day, 1 mo) on the phagocytic activity, serum complement titer, complement-binding antibody titer, basophil degranulation, and neutrophil injury was studied in guinea pigs. Formaldehyde alone stimulated phagocytosis and increased the serum complement titer. Previous irradiation attenuated the immunologic changes caused by the subsequent inhalation of formaldehyde. CO alone increased

the immune reactivity. Previous exposure to microwave radiation protected the immune system from the effect of CO. The changes caused by CO in the immunologic reactivity were eliminated by subsequent exposure to the microwave field of $5 \mu\text{W/cm}^2$, but exposure to $50 \mu\text{W/cm}^2$ had a sensitizing effect after poisoning with CO. The findings indicate that the combined effect of the chemical and physical factors is determined by the character and extent of the sensitizing action of the separate factors.

- 5447 HEMATOLOGICAL EXAMINATIONS ON CHANGES CAUSED BY MICROWAVE WARMING OF BLOOD.
(Ger.) Kaegi, P. (Abteilung Hamatologie, Kantonsspital, Universität Zurich, Ramistrasse 100, CH-8091 Zurich, Switzerland); Rueegg, R.; Straub, P. W.; Hossli, G. *Infusionsther Klin Ernaehr* (4): 285-289; 1977. (11 refs)

The effect of microwave warming on 37 hematologic parameters was studied on donor blood to be used for transfusion. The blood samples were warmed by means of a "Haemotherm" apparatus with a microwave generator (400 W, frequency $2,450 \pm 50$ MHz). The samples were warmed from 11.7 ± 2.6 °C to 31.9 ± 2.0 °C in 75 ± 22 sec. Each characteristic was determined in 5-8 samples. Microwave warming caused significant changes in three parameters only: 82.64% increase of the free hemoglobin level ($p=0.01$) in fresh blood samples, increase in the mean hemoglobin concentration of the erythrocytes ($p<0.05$), and reduction of the partial thromboplastin time ($p<0.05$) in samples stored for 9-10 days prior to warming. The erythrocyte survival time was 26 days before warming and 27 days after warming (normal range 27 ± 3 days). The findings indicate the absence of serious hematologic alterations due to microwave warming.

- 5448 DETECTION OF BREAST CANCER BY MICROWAVE RADIOMETRY. (Eng.) Barrett, A. H. (Dept. Physics and Res. Lab. Electronics, Massachusetts Inst. Technology, Cambridge, MA 02139); Myers, P. C.; Sadowsky, N. L. *Radio Sci* 12(6S): 167-171; 1977. (8 refs)

A microwave radiometer (3.3 GHz) with a dielectric-filled waveguide antenna was used to map thermal radiation from the human body in an effort to detect 26 patients with biopsy-proven breast cancer among 2,000 patients examined with the technique. True positive and true negative rates of detection in excess of 70% were found. These rates were comparable with those obtained by infrared thermography but were inferior to xeromammographic rates of detection for the same set of patients. When the results of microwave radiometric and infrared thermographic data were combined for the 26 breast cancer patients, the true positive detection rate became 96%, which was comparable to the true positive detection rate of 89% for mammography alone. Although the true negative rate of detection for the combination of radiometry and thermography was less than 70% and therefore inferior to the true negative detection rate of 92% for mammography

alone, the lower true negative rate for this combination should not be objectionable for screening patients if the true positive rate is high and if xeromammography is used for followup.

- 5449 NEW ARTIFACT-FREE ELECTRODES FOR RECORDING OF BIOLOGICAL POTENTIALS IN STRONG ELECTROMAGNETIC FIELDS. (Eng.) Tyazhelov, V. V. (Inst. Biological Physics, Acad. Sciences Union Soviet Socialist Republics, Pushchino, Moscow Region, USSR); Tigranian, R. E.; Khizhniak, E. P. *Radio Sci* 12(6S): 121-123; 1977. (4 refs)

The design of artifact-free electrodes for recording biologic potentials in strong electromagnetic fields is reported. Electrodes of high linear resistance (>100 kohms/m) were designed to minimize diffractive problems and control for artifactual stimulation by eliminating spurious currents at the junction between the electrode tip and the biologic preparation. Proper filtration was used to prevent contamination of amplifier-recording circuits by demodulation artifacts. In one experiment on a phantom preparation, the implanted electrode was a glass rod (0.5 mm in diameter and 30 mm in length) with a platinum film. The connecting electrode was a tube (4 mm in diameter and 1 m in length) filled with Ringer's solution. The frequency of irradiation was 0.8 GHz, and the carrier was sinusoidally modulated at 50 Hz (80% modulation). The strength of the E field at the electrode extended to 3 kV/m. Positioning of an electrode was random with respect to the E-field vector. No artifact from demodulation of the carrier was observed, and variations of field strength near loci where the electrodes were in contact with the phantom preparation were no greater than 3dB. These results indicate that simple artifact-free electrodes can be designed for recording bioelectric potentials of animals during exposure to intense electromagnetic fields.

- 5450 A METHOD FOR EXPOSING CELL CULTURES TO ELECTROMAGNETIC FIELDS UNDER CONTROLLED CONDITIONS OF TEMPERATURE AND FIELD STRENGTH. (Eng.) Guy, A. W. (Bioelectromagnetics Res. Lab., Dept. Rehabilitation Medicine, Univ. Washington Sch. Medicine, Seattle, WA 98195). *Radio Sci* 12(6S): 87-96; 1977. (9 refs)

A system for exposing cell cultures to broadband electromagnetic energy under controlled conditions of field strength and temperature is described, which is useful for determining whether effects observed in *in vitro* biologic specimens are athermal or thermal in nature. The system can produce reasonably uniform electric field strengths up to 100 V/cm in a 5-ml sample. It has a continuously controllable input power to 600 W and a frequency range from direct current to 100 MHz and beyond. Control of the sample's temperature over a wide range is achieved by the use of a high-rate circulating-liquid heat exchanger; the cooling capacity is sufficient to maintain one of a wide range of steady-state temperatures during exposure of the sample to a continuous wave field strength in excess of 20 V/cm. Accurate monitoring of the sample's

temperature at frequencies below 100 MHz is achieved during exposures by on-line measurement of feedline impedance. Nonperturbing thermal measurement of the sample can be made at all frequencies by a Teflon-insulated sensor of special design. Data obtained for a 20-min sample exposure of a culture of mesothermal cells to 30.0 MHz at a field strength of 20-22 V/cm show that the average rate of energy absorption is 35 W, and the temperature of the sample is increased approximately 33 C above the coolant temperature due to the heating of the culture by the electromagnetic fields. The specific absorption rate for this case exceeded by two orders of magnitude that normally produced in typical *in vivo* exposures. The system provides a means for exposing living mesothermal cells to field levels far in excess of that which could be applied to mesotherms but at a temperature not exceeding the normal range. Therefore, the flexibility of the system in controlled experiments for assessing athermal effects is demonstrated.

5451 **RADIO-FREQUENCY RADIATION LEVELS IN URBAN AREAS.** (Eng.) Janes, D. E. (Office Radiation Programs, U. S. Environmental Protection Agency, 9100 Brookville Road, Silver Spring, MD 20910); Tell, R. A.; Athey, T. W.; Hankin, N. N. *Radio Sci.* 12(6S): 49-56; 1977. (18 refs)

Data on environmental levels of radio-frequency energy obtained for Atlanta, Boston, Miami, and Philadelphia (15-30 sample sites each) are presented. Median power densities measured at a sampling antenna height of 6.4 m above ground at these locations were $2.8 \times 10^{-5} \mu\text{W}/\text{cm}^2$ for two land-mobile bands (150 and 450 MHz), $1.7 \times 10^{-3} \mu\text{W}/\text{cm}^2$ for low very-high-frequency (VHF) television band (54-88 MHz), $2.1 \times 10^{-3} \mu\text{W}/\text{cm}^2$ for the ultra-high-frequency television band (470-890 MHz), $2.9 \times 10^{-3} \mu\text{W}/\text{cm}^2$ for the high VHF television band (174-216 MHz), and $1.3 \times 10^{-2} \mu\text{W}/\text{cm}^2$ for the frequency-modulated radio broadcast band (88-108 MHz). Frequency-modulated radio broadcast bands contribute the most, and the land mobile bands the least, to environmental radio frequency energy levels between 54 and 900 MHz. Power density values of the standard amplitude-modulated broadcast band were not included in this analysis since current United States exposure standards do not apply to frequencies below 10 MHz. The maximum power density at any site summed over all bands was $2.5 \mu\text{W}/\text{cm}^2$. Four sites fell within the range of $1-2.5 \mu\text{W}/\text{cm}^2$ so that some members of the population are exposed to power densities in excess of $1 \mu\text{W}/\text{cm}^2$, a value that has been recommended as an exposure standard for the general population in the USSR. Differences in power density levels between the different metropolitan areas have not yet been assessed.

5452 **EVALUATION OF AN IMPLANTABLE ELECTRIC-FIELD PROBE WITHIN FINITE SIMULATED TISSUES.** (Eng.) Bassen, H. (Bureau Radiological Health, Food and Drug Admin., 12721 Twinbrook Parkway, Rockville, MD 20852); Herchenroeder, P.; Cheung, A.; Neuder, S. *Radio Sci.* 12(6S): 15-25; 1977. (11 refs)

The feasibility of producing an internal electric field probe for direct *in vivo* electric field measurement was investigated by using a set of miniature isotropic probes to map electric fields within two small spheres of simulated muscle tissue (3.3 cm and 8 cm radii) that were irradiated by 450-, 915-, and 2,450-MHz plane waves. A relatively accurate implantable electric field probe was produced for use at frequencies near 2,450 MHz. By using a 3-mm dipole with an integral, beam-lead, diode chip detector, a degree of independence of the absolute calibration with respect to effects of the dielectric constant of the medium was achieved. Accuracies within 2.5-4.5 dB of theoretically predicted values were obtained at 2,450 MHz using only a free-space calibration and a suitable dipole insulation thickness. At lower frequencies a significant amount of media dependence occurred due to the higher antenna impedance and the high leakage current of the diode. However, even at the lowest frequency (450 MHz) a lack of boundary effects was observed. The shape of the spatial distribution of electric fields within the muscle-equivalent spheres agreed well with theoretically predicted values, even within a few millimeters of the boundary at all of the tested frequencies. For operational use of the probe, an implantation calibration factor can be assigned for a specific frequency. Using this approach, the uncertainty of the measurement for a wide range of biologic media can be minimized to less than 2.5 dB at 2,450 MHz. The *in vivo* measurement capability of the probe was demonstrated in an implantation experiment in a cat's brain. Smaller probe size and flexible signal leads are required, however, for improved biologic suitability and increased accuracy in complex dielectric media.

5453 **MEASUREMENT OF MICROWAVE RADIATION ABSORBED BY BIOLOGICAL SYSTEMS, 2, ANALYSIS BY DEWAR-FLASK CALORIMETRY.** (Eng.) Blackman, C. F. (Health Effects Res. Lab., U. S. Environmental Protection Agency, Research Triangle Park, NC 27711). Black, J. A. *Radio Sci.* 12(6S): 9-14; 1977. (11 refs)

A Dewar flask calorimetric system was used to measure absorbed microwave energy in a standard tissue culture flask and in bodies of dead Chinese hamsters. At microwave frequencies of 2.45 GHz and 1.0 GHz and power densities of 50 and 100 mW/cm², measurements of absorbed microwave energy in the tissue culture flask made with the calorimetric system were in good agreement with those obtained by electrical measurements, direct temperature measurements, and by heating and cooling curves. The ability of the calorimetric system to measure accurately composite specific heat and averaged absorbed energy for bodies of dead Chinese hamsters exposed to 100 mW/cm² of 2.45-GHz plane waves was also demonstrated. Good agreement was apparent for the measurement of composite specific heat of dead Chinese hamster bodies when compared to the value reported for white mice. Overall, the Dewar flask calorimetric system was demonstrated to be an accurate and widely applicable method for determining averaged rates of energy absorption in biological stud-

ies of electromagnetic radiation. Its application is limited by the inability of the user to measure small increments of temperature and by power input which must be fairly high. The method does not provide information on the distribution of energy deposition within a sample and may distort results to the extent that dead animals do not simulate live ones. In spite of these limitations, the method is considered a viable accompaniment to measurements of power density in many laboratories.

5454 EFFECT OF ELECTRICAL FIELD OF INDUSTRIAL FREQUENCY ON SPERMATOGENESIS. (Rus.)

Andrienko, L. G. (A. N. Marzeev Kiev Scientific Res. Inst. General Communal Hygiene, Kiev, USSR); Dumanskii, Ju. D.; Rudichenko, V. F.; Mleshko, G. I. *Vraah Delo* (9): 116-118; 1977. (11 refs)

The effects of electrical field (50 Hz, 5 kV/m, round-the-clock exposure for 1.4-4.5 mo) on the testicles of adult male outbred rats were studied. Unexposed animals served as control. The exposure caused significant reduction of spermatozoa in the cell suspension prepared from one testicle after 3.5 mo exposure (from 56,000,000/ml in the control to 40,000,000/ml, $p < 0.05$) to the same reduced level in animals exposed for 4.5 mo. The percentage of dead spermatozoa in animals exposed for 3.5 mo was 46.4% vs. 23% in the control ($p < 0.05$). Exposure for 1.5 mo caused an increase in the percentage of atypical spermatozoa from 15.9% in the control to 30.7% ($p < 0.01$). Significant reduction of the rate of phosphorylation of adenosine diphosphate was observed in the mitochondria of the testicles after exposure for 3.5 mo ($p < 0.001$). Reduction of the phosphorylating respiration was also observed after exposure for 4.5 mo, while the adenosine diphosphate ratio remained unchanged. The findings indicate that the damaging effect of electrical field on the testicular mitochondria is due to disturbances caused in the testicular circulation.

5455 MEASUREMENT OF MICROWAVE RADIATION ABSORBED BY BIOLOGICAL SYSTEMS, I. ANALYSIS OF HEATING AND COOLING DATA. (Eng.) Allis, J. W. (Health Effects Lab., U. S. Environmental Protection Agency, Research Triangle Park, NC 27711); Blackman, C. F.; Fromme, M. L.; Benane, S. G. *Radio Sci.* 12(6S): 1-8; 1977. (24 refs)

An analytic method for determining microwave energy absorption by fully utilizing data from heating and cooling curves was demonstrated for *in vitro* samples in two different exposure systems. Far field exposures were conducted at 2,450 MHz continuous wave microwave radiation in an anechoic room using 40 ml of 0.15 molar potassium chloride (KCl) solution in a plastic tissue culture flask as the sample. The second exposure system involved a waveguide transmission-line system that was mounted in the sample compartment of a double-beam ultraviolet-visible spectrophotometer. In this case, the sample consisted of 3 ml of 0.02 molar KCl solution contained in a standard 1-cm² cross-section spectrophotometer cell. Data obtained for the far-field exposure were in excellent agreement with

those obtained by using a simple calorimetric method. For exposures in the waveguide system, the measured absorbed microwave dose was found to apply only to a limited portion of the sample in the region near the probe. In contrast to calorimetry, the heating/cooling curve method does not require calibration. Perhaps the greatest advantage of the method is that data from the entire curve are used to estimate the rate of energy absorption, and therefore no approximations are involved. A limitation of the method for both *in vitro* and *in vivo* experiments is that unless there is uniform energy deposition within the sample the energy absorption value obtained will depend on where the probe is placed. The analysis of heating and cooling curves is particularly difficult to apply to *in vivo* experiments because living animals often regulate their body temperature. A potential disadvantage of the method is that increases in temperature of at least 2 or 3°C are needed to obtain reliable heating and cooling data.

5456 CHANGES IN CERTAIN INDICES OF METABOLISM DUE TO RADIOFREQUENCY WAVES OF NONTHERMAL INTENSITY. (Rus.) Demokidova, N. K. (Scientific Res. Inst. Industrial Hygiene Occupational Diseases, USSR Acad. Medical Sciences, Moscow, USSR). *Gig Sanit* (7): 34-38; 1977. (16 refs)

The effect of long-term exposure to low-intensity radiofrequency fields (69.7 MHz, 150 V/m, 1 hr/day for 3 mo; 14.88 MHz, 70 V/m, 4 hr/day for over 6 mo) on certain metabolic indices and on the thyroid, hypophyseal and adrenal functions was studied in 96 adult male rats. Exposure to the high-frequency field caused a significant decrease in the relative weight of the adrenal glands from 16.4 mg% in the control to 14.5 mg% ($p < 0.01$), a decrease in the reticular zone of the adrenal cortex (from 2.32 mm to 1.6 mm²; $p < 0.05$), a significant increase in the height of the follicular epithelium of the thyroid gland (from 9.9 to 12.3 μ , $p < 0.05$), and an increase of the surface area of the medulla of the adrenal gland (from 0.6 to 0.96 mm², $p < 0.02$) at the end of the exposure. Sharp increase in the excretion of water, nitrogen, and electrolytes in the urine was observed at the end of the exposure but reduced diuresis and Na/K ratio of the urine was seen after exposure for 2 wk. The weights of the hypophysis and adrenal gland were increased significantly after exposure for 1 mo. Similar, but less marked changes, were seen in the animals irradiated at the lower frequency. The findings indicate that the radiofrequency field increased the adrenocortical activity. The observed changes in diuresis and electrolyte excretion under the effect of radiofrequency fields appear to be mediated hormonally and are the specific manifestations of the unspecific stress effect of radiowaves.

5457 THE USE OF SHORT-WAVE DIATHERMY AND ULTRASOUNDS IN TREATMENT OF Puerperal Mastitis. (Pol.) Olecha, S. (Zaklad Fizjoterapii Szpitala Bielanskiego, ul. Cegielska 80, 01-809 Warsaw, Poland). *Wiad Lek* 30(19): 1505-1508; 1977. (26 refs)

Combined short-wave diathermy (15 min/day) and ultrasound treatment (10 min/day) was given to 246 women with puerperal mastitis. The patients were in the age bracket 17-42 yr. There were 98 patients with bilateral mastitis. The duration of treatment was 3-6 days in 124 cases, 7-12 days in 86, and 13-22 days in 36. Complete cure was achieved in 85.37% of the patients and considerable improvement in 6.58%. Poor results were obtained in 1.21%, no improvement in 2.44%, and the therapeutic result was unknown in 2.85%. Six patients developed recurrences that disappeared after a second course of treatment. The findings indicate that combined treatment with diathermy and ultrasound should be used more extensively in patients with puerperal mastitis.

5458 EFFECT OF AIR-ELECTRIC FIELDS ON DRIVING AND REACTION PATTERNS. TEST SUBJECTS IN THE CAR DRIVING SIMULATOR. (Eng.) Anselm, D. (Allianz-Zentrum fur Technik GmbH, Krausstrasse 14, D-8045 Ismaning, W. Germany); Danner, M.; Kirmaler, N.; Koenig, H. L.; Mueller-Limmroth, W.; Reis, A.; Schauerte, W. *Munch Med Wochnenschr* 119(23): 813-816; 1977. (17 refs)

The influence of artificial atmospheric electrical fields (generated by +1,000 V on the sun visor and 20 V on the automobile body, 10 Hz) on the driving and reaction pattern was studied in 48 test persons, aged 18-54 yr, in a double-blind test in a driving simulator with optic display. The electrical field had practically no influence on the reaction time; the observed increase by 2% was insignificant. The electrical field improved the driving behavior (improved the concentration and reduced the frequency of driving errors, such as, violations of traffic rules) by 8-10%, especially in labile test persons. The difference from the driving tests without electrical field is not significant. The findings indicate that the electric field has no unfavorable effect on the driving pattern.

5459 FOCAL HYPERTHERMIA AS INDUCED BY RF RADIATION OF SIMULACRA WITH EMBEDDED TUMORS AND AS INDUCED BY EM FIELDS IN A MODEL OF A HUMAN BODY. (Eng.) Chen, K.-M. (Dept. Electrical Engineering and Systems Science, Michigan State Univ., East Lansing, MI 48824); Guru, B. S. *Radio Sci* 12(6S): 27-37; 1977. (10 refs)

In the first of two studies, distributions of rates of electromagnetic (EM) energy absorption were observed in simulated biologic bodies with embedded tumors in an attempt to discover effective means of inducing hyperthermia by high frequency and very high frequency EM fields in tumors. Part- and whole-body simulacra irradiated by EM fields (maximum of 1 V/m) ranging in frequency from 15-500 MHz exhibited differentially greater heating of tumors, and a reduction of the tumor conductivity resulted in an enhancement of the selective tumor heating effect. In a second study, a model of a man irradiated with an incident electric field of 1 V/m over a frequency range of 1-500 MHz was examined. Greater rates of energy absorption oc-

curred in regions of smaller cross section and in tissues with lower conductivities. When the incident EM field was vertically polarized, a major resonance was observed at about 80 MHz, and weaker resonances occurred at 160 and 240 MHz. For the case of horizontal polarization, only a single weak resonant peak was observed near 200 MHz. Overall, the general distribution of specific absorption rates (SAR) of energy compared very well with other experimental results based on a 31-MHz field. However, the absolute values of the SARs deviated by a factor of four to five between theory and experiment. The source of the deviation is not known at present.

5460 STIMULATION OF THE ADRENAL AXIS IN THE MICROWAVE EXPOSED RAT. (Eng.) Lotz, W. G. (Ph.D. dissertation, Univ. Rochester, 1976); 136 pp. [available from Xerox Univ. Microfilms, Ann Arbor, MI 48106, Order No. 77-25,571] (123 refs)

Plasma corticosterone (PC) levels were used as an indicator of adrenal axis function to determine the physiologic mechanism of the adrenocortical response in rats to acute continuous wave microwave (2,450 MHz) exposure. Rats were exposed in the far field of a horn antenna for 30 or 60 min at power densities of 0, 13, 20, 30, 40, 50, or 60 mW/cm² or for 120 min at 0, 13, 20, 30, or 40 mW/cm². The average energy absorption rate of exposed rats was 0.16 W/kg absorbed per mW/cm² incident power. The PC levels exhibited a threshold pattern of response. For 30- or 60-min exposures, no significant increase over control levels was observed below exposures of 50 mW/cm². For 120-min exposures, PC levels were significantly increased at 20, 30, and 40 mW/cm². For all three exposure durations, a strong correlation was evident between mean colonic temperature and mean PC levels. The PC levels in acutely hypophsectomized rats exposed to 60 mW/cm² for 60-min were below control levels. When other rats were pretreated with dexamethasone (DEX) before being exposed to 50 mW/cm² for 60 min, the corticosterone response to microwave exposure was completely suppressed by 3.2 µg DEX/100 g body weight. These results indicate that the microwave-induced corticosterone response observed in normal intact rats is dependent on adrenocorticotrophic hormone secretion by the pituitary; that is, the adrenal gland is not stimulated primarily by microwave exposure. The evidence obtained in these experiments is consistent with the hypothesis that the stimulation of the adrenal axis in microwave-exposed rats is a systemic, integrative process due to a general hyperthermia. These results suggest that adrenocortical function may be a sensitive quantifiable indicator of the physiologic compensation required of an animal exposed to microwaves.

5461 THE EFFECTS OF HIGH VOLTAGE TRANSMISSION LINES ON HONEYBEES: A FEASIBILITY STUDY. (Eng.) Greenberg, B. (Bioconcern, Inc., 1463 East 55th Place, Chicago, IL 60637). 63 pp.; 1977. [available through Electric Power Research Institute, 3412 Hillview Ave., Palo Alto, CA 94304. Publication EPRI EA-489]. (31 refs)

Methodology for the investigation of the effects of electric fields generated by high-tension power lines on honeybees (Dadant's Italian-Starline variety) is described. Preliminary work has established an experimental site under a 7.2-kV transmission line and a control site nearby. The E field strength ranges from 7.0-7.1 kV/m under the 765-kV line at the experimental site and from 10-11 V/m at the control site. Parameters to be measured include colony population, honey stores, the amount of acoustical noise generated by bees, in-hive temperature, incidence of queen cell production, and tendency to swarm. Accompanying dosimetric support includes in-hive electric field measurements, the development of shielding to eliminate the electric field from selected colonies, an analysis of the acoustical data, and periodic checks on the ambient electric field present under the line and at the control site.

5462 THE PROPERTIES OF BIRD FEATHERS AS PIEZOELECTRIC TRANSDUCERS AND AS RECEPATORS OF MICROWAVE RADIATION. (Eng.) Bigu del Blanco, J. (Anatomy Dept., Queen's Univ., Kingston, Ontario K7L 3N6, Canada); Romero Sierra, C. *L'onde Electrique* 57(8/9): 532-536; 1977. (21 refs)

The properties of bird feathers as dielectric receptors of microwave radiation were investigated. Radiation pattern measurements were conducted using the calamus of feathers from the Canadian goose as a receiving aerial for a 16-GHz microwave signal (internally modulated by a 1-kHz square wave) generated by a klystron tube of 250 mW total power output. The length, diameter, and wall thickness of the receiving specimen were 6.95, 0.43, and 0.32 times the operating free-space wavelength. The receiving system consisted of a section of rectangular waveguide to which the feather was directly coupled by a tight fitting elliptical aperture. The waveguide with the elliptical aperture acted as a primary transducer. A substantial increase in the power received in the forward direction along with a decrease in radiation pattern beam width occurred when the feather was in place. The power collected by the feather plus the primary transducer was slightly larger than twice the power collected by the primary transducer alone, and the radiation pattern beam width was reduced by about 43%. It also appeared possible to induce piezoelectric effects in feathers by audiofrequency-pulsed microwave radiation.

5463 THE PROPERTIES OF BIRD FEATHERS AS CONVERSE PIEZOELECTRIC TRANSDUCERS AND AS RECEPATORS OF MICROWAVE RADIATION. II. BIRD FEATHERS AS DIELECTRIC RECEPATORS OF MICROWAVE RADIATION. (Eng.) Bigu-del-Blanco, J. (Anatomy Dept., Queen's Univ., Kingston, Ontario, Canada); Romero-Sierra, C. *Bio-telemetry* 2: 354-364; 1975. (13 refs)

The characteristics of bird feathers as dielectric receptors of microwave radiation (10 and 16 GHz) were investigated. A standard rectangular waveguide, acting as a primary antenna was used as the receiving system for 10- or 16-GHz microwave signals (internally modulated by a 1-kHz square wave) generated by a klystron tube with a total output power

of 250 mW. The feather was directly coupled to the antenna via an elliptical aperture into which the calamus fitted tightly. When the feather was in place, a substantial increase (two to three times) in total power reception in the forward direction along with a 20-50% decrease in half-power beam width was observed. These changes in reception were probably due to microwave field guiding and focussing by the feather. Some evidence that an amplitude-modulated or pulsed microwave electric field can also elicit piezoelectric resonance in the feather receiving system was also obtained.

5464 ORIENTATION EFFECTS ON MICROWAVE-INDUCED HYPERTHERMIA AND NEUROCHEMICAL CORRELATES. (Eng.) Merritt, J. H. (Radiation Sciences Div., USAF Sch. Aerospace Medicine, Brooks AFB, TX 78235); Charness, A. F.; Hartzell, R. H.; Allen, S. J. *J. Microwave Power* 12(2): 167-172; 1977. (11 refs)

The effect of microwave field orientation on body core and brain hyperthermia and on neurochemical changes in the basal hypothalamus of male Sprague Dawley rats was investigated. The animals were individually irradiated with 1,600 MHz continuous wave radiation so that the long axis of the rat was parallel to either the E- or the H-field. In all cases, increases in rectal and brain temperatures of rats exposed in the E-orientation were greater than in rats exposed in the H-orientation. Rats exposed in the H-orientation to 20 mW/cm² microwave power for 10 min did not show increases in either brain or rectal temperature compared with controls; whereas, modest increases in both brain and rectal temperatures were observed in rats exposed at this power level for 10 min in the E-orientation. No changes in rectal or brain temperature were seen in E-oriented or H-oriented rats exposed to a power of 10 mW/cm². When rats were exposed for up to 2 hr to 20 mW/cm² of 1,600-MHz radiation, brain and rectal temperatures remained fairly constant from 1-2 hr after the commencement of radiation. Upon cessation of power, both brain and rectal temperatures declined rapidly, and the animals were normothermic within 10 min. In rats exposed to 1,600 MHz radiation in the E-orientation, norepinephrine levels in the basal hypothalamus were significantly reduced from a control value of 1,463 ± 191 ng/g brain tissue to levels of 1,225 ± 155, 1,043 ± 86, and 1,075 ± 231 ng/g after a 10-min exposure to 20 mW/cm², a 60-min exposure to 20 mW/cm², and a 10-min exposure to 80 mW/cm². These same exposures resulted in insignificantly reduced dopamine levels of 665 ± 138, 680 ± 175, and 644 ± 195 ng/g, respectively, compared with a control value of 829 ± 230 ng/g. The content of serotonin in the basal hypothalamus was unaltered at the highest power level (80 mW/cm²), which resulted in a 5°C increase in brain temperature.

5465 THERMOGRAPHIC AND BEHAVIORAL STUDIES OF RATS IN THE NEAR FIELD OF 918-MHz RADIATIONS. (Eng.) Lin, J. C. (Dept. Electrical Engineering, Wayne State Univ., Detroit, MI 48202); Guy, A. W.; Caldwell, L. R. *IEEE Trans Microwave Theory Techniques* 25(20): 833-836; 1977. (10 refs)

Incident and absorbed energy were measured in female Sprague-Dawley rats to determine levels that disrupt operant behavior. After base-line performances were recorded, rats were exposed to four levels of 918 MHz radiation (0, 10, 20, 40 mW/cm²). The distance between the proximal surface of the animal's body and the radiator was 8 cm. Rats were killed, and each reassembled rat carcass was irradiated for 30 sec at 1,500 mW/cm². The temperature patterns were determined using computerized thermographs. Peak absorption of energy in the body was estimated to be 0.8 W/kg per 1 mW/cm² of incident energy, while the value for the tail was 0.9 W/kg. Operant responses of irradiated rats to schedules of fixed-ratio (food) reinforcement under the same conditions as the dosimetric test were observed to occur for 30-min exposures to averaged power densities of 30-40 mW/cm². This range of densities corresponds to absorbed peaks of energy of 27-36 W/kg. No change in behavior was observed for incident power densities and peaks of absorbed energy ranging from 20-30 mW/cm² and 18-27 W/kg, respectively. All behavioral changes at higher values were reversible.

5466 MODIFICATION OF REPAIR OF X-IRRADIATION DAMAGE OF HEMOPOIETIC SYSTEM OF MICE BY MICROWAVES. (Eng.) Rotkovska, D. (Inst. Biophysics, Czechoslovak Acad. Sciences, Brno, Czechoslovakia); Vacek, A. J. *Microwave Power* 12(2):120-123; 1977. (7 refs)

Microwaves (2,450 MHz, 100 mW/cm²) were used to modify X-irradiation damage of the hemopoietic system in C57Bl/10 strain mice. Mice exposed for 5 min to microwaves 30 min after X-irradiation (600, 650, 700, or 750 R) had a significantly higher survival percentage than X-irradiated controls. At the lowest X-ray dose, the survival percentages on day 30 after X-ray exposure were about 100% for microwave-treated mice and about 75% for X-irradiated controls. At the highest X-ray dose, the survival percentages of microwave-treated and control mice were about 30 and 0%, respectively. Microwave-treated mice also manifested an increased number of surviving hemopoietic stem cells and heightened erythropoiesis and myelopoiesis. Significant increases in the number of hemopoietic endogenous spleen colonies (ESC) in the spleens of mice exposed to microwave irradiation at 0.5, 6, and 12 hr after a 300-R X-ray exposure were seen in relation to controls, and these increases support earlier observations of an elevation in the number of stem cells in the spleens of intact mice after microwave exposure alone. These results indicate that microwaves may influence the mechanisms that activate the pool of stem cells. Since ESC grow from the hemopoietic stem cells that survive X-irradiation, the increase in their number may be due either to an improvement of the repair of sublethal radiation damage of the irradiated stem cells or to increased proliferation of the stem cells that survive X-irradiation. An acceleration of the repair processes of radiation damage of hemopoietic cells appears to occur following microwave exposure, and this acceleration is dependent on the stage of intracellular repair at the time of microwave exposure.

5467 A SIMPLE RADIOPROOENZYMIC PROCEDURE FOR THE DETERMINATION OF CHOLINE AND ACETYLCHOLINE IN BRAIN REGIONS OF RATS SACRIFICED BY MICROWAVE IR-RADIATION. (Eng.) Eckernaes, S.-A. (Dept. Neurology, Univ. Hosp., Uppsala, Sweden); Aquilonius, S.-M. *Acta Physiol Scand* 100(4): 446-451; 1977. (22 refs)

A rapid and sensitive radioenzymatic method for the analysis of choline (Ch) and acetylcholine (ACh) concentrations in brain tissue from rats sacrificed by microwave irradiation is described. The method is a modification of a previously used radioenzymatic procedure for Ch and ACh determination based on enzymatic acetylation of free Ch with ¹⁴carbon-labeled acetyl-coenzyme A using purified choline acetyltransferase. After ion-pair extraction of ¹⁴carbon-labeled ACh formed, which is performed directly in the scintillation vial using tetraphenylboron, radioactivity is measured by liquid scintillation counting. In one aliquot of a brain extract, endogenous ACh is specifically hydrolyzed by means of ACh-esterase, and the total Ch concentration of the sample is determined. The concentration of endogenous Ch is measured in an unhydrolyzed aliquot, and the ACh level is then obtained as the difference in Ch concentration between the two aliquots. About 120 determinations can be performed in 1 day. Measurements of Ch and ACh in the brains of rats killed by 5 kW of 2,450-MHz microwave irradiation for 1.7 sec revealed that the ACh content was 16 ± 1.0 nmol/g in the cortex and 76 ± 2.4 nmol/g in the striatum; the corresponding Ch values were 23 ± 2.5 and 33 ± 1.2 nmol/g, respectively.

5468 FURTHER STUDIES ON THE MICROWAVE AUDITORY EFFECT. (Eng.) Lin, J. C. (Dept. Electrical and Computer Engineering, Wayne State Univ., Detroit, MI 48202). *IEEE Trans Microwave Theory Techniques* 25(11): 938-943; 1977. (26 refs)

A theoretical study of the acoustic signal generated in the heads of humans and laboratory animals irradiated with rectangular pulses of microwave energy is presented. Assuming that auditory sensation results from acoustic waves generated in the tissues of the head by rapid thermal expansion of the tissues upon microwave absorption, the amplitude and frequency of the auditory signal are derived for a homogeneous spherical model of the head under constrained-surface conditions. The results indicate that the frequency of the auditory signals generated is independent of both the frequency of the incident microwave and the absorbed energy distribution; rather, the frequency of the induced auditory signal is only a function of head size and tissue acoustic property (velocity of acoustic wave propagation). The smaller the head size, the higher the frequency of the microwave-induced auditory sensation. For example, in guinea pigs with a head size of 1.5-2.5 cm, the frequency of the induced auditory sensation is predicted to range from 40-70 kHz as compared with 10-15 kHz for an adult human head with a size of 7-10 cm. Although the amplitude and frequency of microwave-induced sound are higher when predicted by the above method than when predicted by stress-free boundary condition formulation, they are compatible with experimental

results reported to date. It is also shown that there is an optimum pulselwidth for the efficient conversion of microwaves to acoustic energy. For a 3-cm radius sphere exposed to 2,450 MHz radiation at a peak absorbed microwave energy of 1,000 mW/cm³, an optimum pulselwidth of about 2 μ sec is predicted for pressure generation to occur.

- 5469 NEW CLASS OF MICROWAVE SHIELDING MATERIALS. (Eng.) De Bruyne, R. (Centrum voor Onderzoek, N. V. Bekaert S.A., B-8550 Zwevegem, Belgium); Van Loock, W. *J. Microwave Power* 12(2): 145-154; 1977. (12 refs)

A new class of microwave-shielding materials based on the use of fine stainless steel Bekinox fibers is discussed. These metal fiber products show controllable microwave reflection and absorption properties. By changing the diameter, length, concentration, and total quantity of the shielding material, a large range of shielding effectiveness (SE) values can be covered, while the ratio between absorption and reflection can be changed. Needle felt materials, which show higher SE values than web materials, can be produced with SE values of >30 dB for S-band and >60 dB for X-band radiation. Noncompressed webs with fiber diameters of 4, 8, 12, and 22 μ m and surface weights between 100 and 280 g/m² show SE values of greater than 25 dB for S-band and greater than 50 dB for X-band radiation. Woven materials of the mesh type give SE values greater than 30 dB for a metal content of 12%. Products made from metal fiber materials can be used in applications such as radar camouflage, radiation protection, and gasket construction.

- 5470 SOME EFFECTS OF 3300 MHZ MICROWAVES ON OXYGEN UPTAKE IN GERMINATING PEAS. (Eng.) Carley, A. L. (Ph.D. dissertation, Univ. Wisconsin-Milwaukee, 1976); 138 pp. [available from Xerox Univ. Microfilms, Ann Arbor, MI 48106, Order No. 77-15,989]. (145 refs)

The effects of low-level 3,300-MHz microwave irradiation for 10 min on oxygen uptake in germinating seeds of peas (*Pisum sativum*) was investigated. A dose-dependent reduction in the rate of oxygen consumption was observed during irradiation. At an incident power of 5 mW/cm², there was a 49.6% decrease in oxygen consumption rate. At incident energies of 3.5, 2, and 1 mW/cm², the oxygen consumption rate was reduced by 27.9, 25.1, and 14.4%, respectively. There was no observable rate difference between peas irradiated at 0.5 mW/cm² and nonirradiated control germinating peas. Older peas were less affected than younger ones by the incident microwaves. The microwave effect was diminished by the presence of an external source of glucose. The microwave effect was a nonthermal one, and any microbial flora present did not noticeably affect the peas' gas exchange patterns during irradiation. Externally supplied glucose was absorbed and utilized by the rapidly metabolizing germinating pea seed. When external glucose was supplied before microwave irradiation, this effect was diminished, indicating a microwave effect somewhere in the metabolic pathway that sup-

plies glucose for respiration. The most likely pathway affected is that of phosphoryllic breakdown of stored starch. This pathway is active at the stage of germination investigated, involves a number of intermediate steps to produce glucose, and has a number of potential microwave targets. In general, the data indicate that the 10-min irradiations at low intensities (5 mW/cm²) of 3,300 MHz microwaves affect the ability of germinating peas to utilize and evolve carbon dioxide.

- 5471 ELECTROMAGNETISM, MAN AND THE ENVIRONMENT. (Eng.) Battocletti, J. H. (Boulder: Westview Press): 89 pp.; 1976. (150 refs)

A review of the effects of electric, magnetic, and electromagnetic fields on human physiology is presented. Topics covered include specific sources of man-made electromagnetic fields; obvious thermal effects on man, particularly from ultra-high frequency radiation and microwaves; lesser known non-thermal physiologic effects in man; therapeutic uses of electric and magnetic fields; and electromagnetic exposure standards in the United States, Russia, and other countries. The effects of thermal electrical pollution are distinguished from the effects of athermal pollution, and the results of several surveys on the athermal effects induced by electromagnetic fields are presented, such as, the phosphene phenomena or sensation of light flashes in the eye (800 G, 30-40 Hz); radiosounds (250 mW/cm² peak; 1-7 mW/cm² average; 200-3,000 MHz modulated); cardiovascular effects (1 mW/cm² ultra-high frequency; 10-100 V/m shortwave; 100-1,000 V/m medium wave); conditioned vascular reflex (10,000 V/m high frequency); and reaction time effects (5-17 G [direct current] modulated at 0.1-0.2 Hz).

- 5472 NEURONAL AND EXTRANEURONAL OUTFLOW OF ³H-NORADRENALINE INDUCED BY ELECTRICAL-FIELD STIMULATION OF AN ISOLATED BLOOD VESSEL. (Eng.) Schrold, J. (Dept. Pharmacology, Univ. Odense, Denmark); Nedergaard, O. A. *Acta Physiol Scand* 101(2): 129-143; 1977. (32 refs)

The adrenergic neuronal selectivity of tritium (³H)-outflow elicited by electrical field stimulation of rabbit isolated pulmonary artery preloaded with ³H-(β)-noradrenaline (³H-NA) was examined. Following incubation (45 min) of arterial rings at 37°C with ³H-NA (10^{-6} molar) and a 100-min washout period, the sympathetic neurons were stimulated selectively and supramaximally with a constant current (250 mA; 300 monophasic pulses; 10 Hz; 0.3 msec). The initial stimulation-induced ³H outflow was 39 picomoles/g, which was higher than the subsequent five outflows that remained almost constant (20, 19, 17, 16, and 16 picomoles/g, respectively). ³H-NA and ³H-O-methylated plus deaminated metabolites constituted 11 and 74%, respectively, of the total ³H outflow induced during the initial stimulation period and 38 and 38%, respectively, of the total ³H outflow during the second stimulation period. The omission of calcium ion in the physiological salt solution reduced the six stimulation-induced outflows to 67,

40, 35, 24, 21, and 21%, respectively, of untreated preparations. Bretylium (3×10^{-5} molar) or tetrodotoxin (10^{-6} molar) reduced the ^3H outflow to approximately the same extent. Stimulation-induced outflows from artery rings preloaded with $^3\text{H-NA}$ in the presence of cocaine (10^{-3} molar) or in the cold (3°C) approximated the calcium ion, bretylium, and tetrodotoxin-insensitive release. These treatments all completely blocked the neurogenic contractile response. When artery rings were preloaded with $^3\text{H-NA}$ in the presence of normetanephrine (10^{-4} molar), the stimulation-induced calcium ion insensitive outflows were markedly reduced. These results indicate that ^3H outflow represents release from neuronal and extraneuronal sites.

5473 VOLTAGE-INDUCED PORE FORMATION AND HEMOLYSIS OF HUMAN ERYTHROCYTES. (Eng.) Kinoshita, K. (Dept. Physiological Chemistry, Johns Hopkins Univ. Sch. Medicine, Baltimore, MD 21205); Tsong, T. Y. *Biochim Biophys Acta* 471(2): 227-242; 1977. (22 refs)

Isotonic suspensions of human erythrocytes were exposed to single electric pulses of a few kV/cm intensity and of microsecond duration to study hemolysis and pore formation. Upon pulsation, the cell membranes became permeable to sodium and potassium, and the erythrocytes eventually hemolyzed through the colloid osmotic effect of hemoglobin. The enhanced permeability was attributed to the formation of pores in the cell membranes. These pores were formed within a fraction of a microsecond once the transmembrane potential induced by an applied electric field with a pulse duration of 20 usec reached a critical value of 1.0 V. Increased field intensity or pulse duration or pulsation at low ionic strengths resulted in an expansion of pore size, leading to an accelerated hemolysis reaction. In contrast to this expansion process, the initial step of pore formation was governed solely by the magnitude of the transmembrane potential, the critical value of which remained essentially constant in media of different ionic strengths and did not change appreciably with varying pulse duration. An abrupt increase in membrane permeability at a transmembrane potential of about 1 V has been observed in many cellular systems, and it is suggested that a similar mechanism of pore formation may apply to these systems as well.

5474 INTRACARDIAC CATHETER FIBRILLATION THRESHOLDS AS A FUNCTION OF THE DURATION OF 60 HZ CURRENT AND ELECTRODE AREA. (Eng.) Roy, O. Z. (Natl. Res. Council Canada, Ottawa, Ontario, Canada); Park, G. C.; Scott, J. R. *IEEE Trans Biomed Eng* 24(5): 430-435; 1977. (12 refs)

Fibrillation thresholds and their relationship to the duration of 60-Hz current flow (expressed as the number of 60-Hz cycles applied to the heart) are described. Experiments were performed on 50 healthy beagle and labrador dogs using catheter electrodes ranging in surface area from 0.224 mm^2 to 90 mm^2 . The electrodes were introduced through the azygous vein into the right ventricle and were located at

or near the apex. Current fibrillation thresholds were found to be exponentially related to the number of 60-Hz cycles flowing through the heart. Current fibrillation thresholds were increased with greater electrode surface areas. However, as the number of 60-Hz cycles was reduced, the dependence of fibrillation thresholds on electrode area was also reduced so that at one cycle of 60 Hz current fibrillation thresholds were approximately equal for the above range of electrode surface areas. At current flow durations of 10 cycles of 60 Hz or less, smaller electrodes required more energy to fibrillate the heart because of polarization phenomena. There was an amplitude dependent fibrillation window that had an upper and lower limit between which fibrillation was most likely to occur. The ratio between the average upper and lower level values for 16 cycles of 60-Hz and less was 3:1. The ratio difference in fibrillating current thresholds between rheobase values and values at one cycle of 60 Hz was in excess of 100:1.

5475 ELECTROMAGNETIC POLLUTION. (Eng.) Becker, R. O. (Veterans Admin. Hosp., Syracuse, NY); Marino, A. A. *Sciences* 18(1):14-15, 23; 1978. (0 refs)

The biological effects of 60-Hz nonionizing electromagnetic radiation are discussed with particular reference to high-voltage transmission line sources. Rats exposed to a 60-Hz electric field for 1 mo exhibited hormonal and biochemical changes similar to those caused by stress. The electric field used in this study was comparable in strength to that produced at ground level by a typical high-voltage transmission line. In another experiment where three generations of rats were continuously exposed to the electric field, increased infant mortality and severely stunted growth were observed. These results appear to indicate that the applied electric field primarily affects the central nervous system and activates the stress-response mechanism. High-voltage transmission lines currently being constructed will operate at 765,000 V compared with the present maximum of about 500,000 V, and the electric utility industry has begun developing the technology to operate at more than 1,000,000 V. It is suggested that this may be the time to halt such technology until studies establish safe levels for humans and for the entire ecosystem.

5476 BIMANUAL BIPOLAR DIATHERMY FOR TREATMENT OF BLEEDING FROM THE ANTERIOR CHAMBER ANGLE. (Eng.) Michels, R. G. (Wilmer Inst., Room 116, Johns Hopkins Hosp., Baltimore, MD 21205); Rice, T. A. *Am J Ophthalmol* 84(6): 873-874; 1977. (12 refs)

A modified bimanual bipolar diathermy technique was used to treat bleeding vessels in the anterior chamber angle of the eye in two patients. One lead of a Mentor Wet Field coagulator was attached to an instrument positioned in the anterior chamber angle at the bleeding site, and a second lead was attached to a needle positioned externally at the corneoscleral limbus in the same meridian. Repeated applica-

tions of diathermy current (approximately 1-sec durations) between the instrument tips were used to coagulate the bleeding vessels. No undesirable effects involving the corneoscleral limbal tissue were noted after diathermy applications in these cases.

- 5477 REGIONAL LEVELS OF CYCLIC AMP IN RAT BRAIN: PITFALLS OF MICROWAVE INACTIVATION. (Eng.) Lenox, R. H. (Dept. Medical Neurosciences and Endocrinology and Metabolism, Walter Reed Army Inst. Res., Walter Reed Army Medical Center, Washington, DC 20012); Meyerhoff, J. L.; Gandhi, D. P.; Wary, H. L. *J. Cyclic Nucleotide Res.* 3(5): 367-379; 1977. (40 refs)

Various microwave systems were evaluated for their ability to inactivate *in vivo* regional levels of cyclic adenosine monophosphate (AMP) in rat brain. The microwave inactivation techniques evaluated were whole body/oven cavity, whole body/restricted area in oven cavity, head immobilized/waveguide chamber, and head/waveguide chamber. Forward powers ranged from 1.25-5.2 kW, and exposure times for cyclic AMP inactivation ranged from 2.25-60+ sec. The rate of inactivation varied in different brain regions (hypothalamus, cortex, and cerebellum) and was reproducible only with immobilization of the rat's head during exposure. As the exposure duration required for cyclic AMP inactivation decreased, the levels of cyclic AMP in some brain regions were significantly reduced, while levels in other regions were unchanged. As the time for adequate cyclic AMP stabilization was decreased, the cyclic AMP values throughout the brain regions generally decreased and became less variable from region to region. It is suggested that with slower microwave inactivation systems significant enzyme-mediated postmortem artifact may persist. These findings demonstrate that different regions of the rat brain require different durations of microwave exposure to stabilize the cyclic AMP levels, suggesting a gradient of enzyme inactivation within the rat brain. The reliability of a particular inactivation method for use with a specific metabolite is dependent on both the lability of the enzyme systems and their activity during the postmortem period. At present it is feasible to use microwave techniques to study cyclic AMP levels in rat whole brain or specific regions, if the exposure durations are based on a consistent known sequence of regional inactivation under the particular microwave parameters employed.

- 5478 RADIATION-INDUCED INJURIES OF THE EYES. (Swe.) Tengroth, B. (Karolinska sjukhuset, Oegonkliniken, Sweden). *Tidsskr Nor Laegeforen* 97(23): 1158-1162; 1977. (13 refs)

Studies on the effects of ionizing and non-ionizing radiation on the eyes are reviewed. Microwave energy (0.3-1,000 mm) is transformed into heat, as it is absorbed by the tissues of the eye and the eye cataract is caused by this thermal effect. Discrete changes in the lens and injury to the retina have been observed in a group of engineers exposed to

microwaves (parameters not given). Reduction of the visual acuity from 1.0 to 0.4 was seen in two of them. Radiation with wavelengths of 1-100 m has not been found to be injurious to the eyes. At an energy density of 20 mW/cm², such radiation levels caused stress in experimental animals.

- 5479 A GAUSSIAN-BEAM LAUNCHER FOR MICROWAVE EXPOSURE STUDIES. (Eng.) Neelakantawamy, P. S. (Dept. Electrical Engineering, Indian Inst. Technology, Madras, India); Gupta, K. K.; Banerjee, D. K. *IEEE Trans Microwave Theory Techniques* 25(5): 426-428; 1977. (10 refs)

A method of producing a focused microwave beam by means of a launcher, consisting of a homogeneous dielectric sphere illuminated by a corrugated cylindrical waveguide aperture (scalar horn), is described. The corrugated pipe has quarter-wave teeth and carries the hybrid (HE₁₁) mode. The field distribution at the aperture of the corrugated pipe is used as the sphere-illuminating source, and the dielectric sphere is placed in front of, but displaced from, this aperture. The waveguide-to-sphere offset can be the optimum value for which the input standing wave ratio is a minimum. This launcher produces a near-circular Gaussian beam in the proximity of the dielectric sphere with a high on-axis gain factor. Near-field measurements performed at a frequency of 9.654 GHz with a dielectric sphere having a relative permittivity of 2.35 (polyvinyl chloride) and a diameter equal to 8.5 cm confirmed theoretic expressions derived for the electromagnetic fields of the focused beam wave. The results indicate that by proper choice of the sphere diameter to wavelength ratio and the scalar horn dimensions, a specified Gaussian beam can be produced for localized exposure of biologic subjects.

- 5480 REACTIVITY OF BONE MARROW MEGAKARYOCYTES IN ALBINO RATS EXPOSED TO LOW-INTENSITY MICROWAVE ELECTROMAGNETIC FIELD. (Rus.) Obukhan, E. I. (Scientific Res. Inst. General and Municipal Hygiene, Kiev, USSR). *Tsitol Genet* 11(1): 27-29; 1977. (9 refs)

The effects of exposure to microwave electromagnetic field (2,375 MHz) on bone marrow megakaryocytes were studied in adult white Wistar rats. The animals were exposed to 500 mW/cm² field for 6 hr or to a 50 mW/cm² field for 6 hr daily on 3, 7, or 10 consecutive days. The animals were killed 1-16 days after exposure. Most mature megakaryocytes were found in the state of thrombocytopoiesis. Part of the mature megakaryocytes were destroyed within 16-24 hr after irradiation; their cytoplasm became oxyphilic and swollen; the nuclei were pyknotic and eccentric. Enucleation was observed. Phagocytosis of lymphocytes, normoblasts, mature granulocytes, and erythrocytes by megakaryocytes was seen. Intensification also caused proliferation of megakaryocytes and promegakaryocytes. The number of thrombocyte-producing megakaryocytes was reduced considerably 7-16 days after exposure, and no destroyed forms were seen after 16 days. These changes were

most pronounced after single exposure to 500 mW/cm² and correlated with the number of exposures to 50 mW/cm².

5481 X-RAY DIFFRACTION ANALYSIS OF BEEF SUET
EXPOSED TO STATIONARY MAGNETIC FIELD.

(Rus.) Lapshev, Iu. A. (Voronezh Correspondence Sch. of Commerce, Voronezh, USSR). *Pischevaya Tekhnologiya* (5): 112-116; 1977. (6 refs)

The effect of stationary magnetic field (0.155 or 0.22 tesla, exposure for 3 min) on the structure of melted beef suet in liquid and solid forms was studied by x-ray diffraction analysis at -10°C. The exposure caused a reduction of the mean width and of the overall intensity of the diffraction lines. Shifts of the intensity maxima, the disappearance of some diffraction lines and the appearance of others were seen in some cases. These changes indicated the development of defects in the crystal lattice, changes in structure, and consequently of changes (increase or decrease) in the reactivity of the compounds forming the fat due to the electron shifts. The structural changes were slightest in specimens exposed in liquid form to a magnetic field of 0.22 tesla and in those treated in solid form with 0.155 tesla.

5482 THE EFFECT PRODUCED BY THE ULTRAHIGH-FREQUENCY EMF ENERGY ON THE ORGANISM OF TEST ANIMALS UNDER DIFFERENT CONDITIONS OF ULTRAVIOLET IRRADIATION. (Rus.) Gabovich, R. D. (Medical Inst., Kiev, USSR); Shutenko, O. I. *Gig Tr Prof Zabol* (9): 31-37; 1977. (6 refs)

Effects of ultra-high-frequency (UHF) fields (2,840 MHz, field intensity 100 or 1,000 μ W/cm², exposure 3 hr/day for 4 mo) were studied in male white rats treated with low (20-25 micro-erythema units/cm²), optimal (400 micro-erythema units/cm²) and high (1,600 micro-erythema units/cm²) doses of ultraviolet (UV) radiation. Group 1 received only low UV dose; Group 2 received low UV dose with UHF (100 μ W/cm²); Group 3 received low UV dose and UHF (1,000 μ W/cm²); Group 4 received optimal UV dose; Group 5 received optimal UV dose and 100 μ W/cm²; Group 6 received optimal UV dose and 1,000 μ W/cm²; Group 7 received high UV dose; Group 8 received high UV dose and 100 μ W/cm²; and Group 9 received high UV dose and 1,000 μ W/cm². The effects of the UHF field and UV irradiation were assessed on the basis of such physiologic parameters as weight gain, performance capacity, latency of the unconditioned defense reflex, blood serum cholinesterase activity, blood SH-group content, immunological reactions, and color sensitivity of the eye. The harmful effect of UV deficit was aggravated by UHF irradiation, especially at the 1,000 μ W/cm² intensity, and the harmful effect of UHF irradiation with μ W/cm² was lessened by treatment with the optimal UV dose considerably, compared with Group 2. The optimal UV dose offered significantly less protection against the harmful effect of UHF of 1,000 μ W/cm² (Group 6). The unfavorable changes in physiologic parameters were most pronounced in Groups 8 and 9, indicating the

synergistic effect of UV and UHF irradiation. The findings indicate the usefulness of the prophylactic UV treatment of subjects exposed to UHF radiation, especially in northern regions and during the fall and winter periods.

5483 CALLUS FORMATION IN TROCHANTERIC FRACTURES DURING ELECTRIC STIMULATION OF OSTEOGENESIS. (Rus.) Iumashev, G. S. (Clinic Traumatology Orthopedics, I. M. Sechenov First Moscow Medical Inst., Moscow, USSR); Kriukov, B. N. *Khirurgia (Mosk)* (12): 62-66; 1977. (18 refs)

The efficiency of electrical stimulation of reparative osteogenesis with weak direct current (parameters not given) was studied in 50 patients (av age 73.2 yr) with trochanteric fracture of the femur. All patients were in skeletal traction, and electrical stimulation was begun 1-2 days after hospitalization. Three hundred and forty-eight patients (av age 72 yr) with similar fractures, who were put into skeletal traction without stimulation, served as controls. The average length of the hospital stay of stimulated patients was 47.7 days vs. 69.4 days in the control; it was possible to remove the traction of stimulated patients after 35.2 days vs. 52.4 days in the control. Electrostimulation reduced the length of traction by 2 wk in nearly 70% of the patients. Callus formation was observed in the stimulated patients 3-4 wk after hospitalization. (Control data not given). The incidence of immobilization-related complications was 12% vs. 24.5% in the control. Earlier normalization of the electrical resistance of the fractured zone was observed in the patients who received electrostimulation compared with the control. The therapeutic results in the stimulated group were excellent in 21 cases, good in 14, satisfactory in 8 (control data not given). The findings indicate the favorable effect of electrical stimulation on osteogenesis.

5484 TREATMENT OF CHRONIC INFLAMMATORY DISEASES OF THE FEMALE GENITALS BY PERMANENT MAGNETIC FIELD. (Rus.) Suvorova, N. M. (Inst. Obstetrics Gynecology, USSR Acad. Medical Sciences, Leningrad, USSR). *Akush Ginekol* (9): 62-63; 1977. (2 refs)

Forty-nine women with chronic salpingo-oophoritis and 25 with chronic perimetritis were treated with a permanent magnetic field (100-300 Oe) by rubber sheets embedded with barium ferrite powder, for 3-4 wk in the hypogastric and lumbosacral region. The patients were aged 21-42 yr, and the length of the disease before the magnetic therapy was 1-4 yr in 26 cases, 5 yr or more in 48. All patients had rather frequent acute exacerbations of the disease, and all had been treated with drugs and physical therapy. The magnetic therapy led to the cessation or alleviation of pain in 12-15 days in 62/74 patients. Objective clinical improvement was seen in 60 cases. The magnetic therapy did not modify the character of the menstrual cycle, and it reduced the blood loss in nine patients who suffered from menorrhagia before the treatment. Normalization of

the erythrocyte sedimentation rate was seen after therapy in all 38 patients who had increased sedimentation rate before treatment. The peripheral blood leukocyte count averaged $5,460 \pm 324$ per mm^3 before treatment, and $6,167 \pm 312$ per mm^3 after therapy. C-reactive protein, found in 25 patients before the treatment, was not seen at all after therapy. Follow-up at 9 mo after therapy showed complete cessation of pain in 36 patients. Eleven patients showed exacerbation of the inflammatory process shortly after the therapy. Placebo treatment, performed on 10 patients, was ineffective. The findings indicate the value of ambulant magnetic therapy in women with inflammation of the internal genitalia.

- 5485 HAZARDS OF HIGH-FREQUENCY ELECTROMAGNETIC FIELDS IN INDUSTRY. (Pol.) Karczmarzowa, T. (No affiliation given); Lipowczan, A.; Tengler, M. *Ochrona Pracy* 31(9): 12-13, 1977. (5 refs)

An inquiry was conducted during the 1975-1976 period in industrial plants, institutions, and hospitals in the Katowice area to determine the number of sources of high-frequency electromagnetic fields. Four hundred and two sources of electromagnetic fields were found in 335 of the 985 industrial plants, institutions, and hospitals queried. The frequencies were under 1 kHz at 6 sources, under 100 kHz at 57, under 1 MHz at 52, under 10 MHz at 275, and under 100 MHz at 62. Two hundred and eighty-nine sources were found in hospitals; their frequencies were in the range of 1-100 MHz, and their outputs ranged from 100 W to 10 kW. The inquiry will be continued to establish the number of persons exposed to electromagnetic fields.

- 5486 NATIONAL CONFERENCE ON THE EFFECT OF ELECTROMAGNETIC FIELDS ON THE BODY. (Slo.) Puzjak, I. (No affiliation given). *Elektrotehnika Casopis* 28(9): 704; 1977. (0 refs)

Papers presented at the National Conference on the Effects of Electromagnetic Fields on the Body, held on May 11-12, 1977 in Prague, Czechoslovakia, are reviewed. Papers on the physical aspects of the problem were concerned mainly with the measurement of electrostatic and electromagnetic fields. Papers on the biological and medical aspects of exposure dealt with the effects of electrostatic and electromagnetic fields on atmospheric ions, with the circadian rhythm of humans in the geomagnetic field, with the influence of magnetic fields on the ^{86}Rb distribution in mice, and with the possible mechanism of the influence of the geomagnetic field on sleep.

- 5487 COMMENT ON "EXPERIMENTAL AND THEORETICAL STUDIES ON ELECTROMAGNETIC FIELDS INDUCED INSIDE FINITE BIOLOGICAL BODIES" (LETTER TO EDITOR). (Eng.) Bassen, H. I. (Div. Electronic Products, Bureau Radiological Health, Food and Drug Admin., Rockville, MD 20852); Cheung, A. *IEEE Trans Microwave Theory Techniques* 25(7):623-624; 1977. (8 refs)

A miniature isotropic probe for measuring electromagnetic fields induced inside finite biologic bodies that is neither location dependent nor calibration dependent with respect to the dielectric properties of the surrounding media is described. Thin-film microminiaturized circuitry was used to produce an electrically small dipole (2.5 mm tip-to-tip) with an integral beam-lead diode chip detector. No bonding wires were present to resonate with the very low reverse bias capacitance of the diode (0.1 picofarads). A layer of low-dielectric constant encapsulation, less than one-quarter wavelength in the media, surrounded the dipole. The performance of the probe was evaluated by performing continuous scans within muscle-equivalent spheres irradiated by a plane wave at a frequency of 2,450 MHz. Good agreement of the spatial distribution of fields existed between the experimental data and theoretically predicted values. The authors conclude that this practical probe eliminates the problems detailed by Guru and Chen. In a second comment, the authors point out that the proper size is critical in the design of an accurate internal field probe. The extent of miniaturization possible with a probe antenna is limited because an excessively small probe's impedance will greatly exceed the equivalent load impedance of even a micro-miniature diode chip, even if the antenna is insulated. An optimum size for an antenna is about 0.1 wavelength in the highest dielectric constant medium to be encountered. Difficulties in making probes response independent of the media at frequencies below 1,000 MHz have been encountered due to the above limitation.

- 5488 USE OF SINUS-MODULATED CURRENTS AND ULTRASOUND IN OBLITERATIVE DISEASES OF THE LOWER LIMBS. (Rus.) Nesterova, V. P. (Dept. Therapy, Kuban Medical Inst., Kuban, USSR); Iarovaia, M. K. *Vrach Delo* (7): 28-30; 1977. (0 refs)

Twenty-nine patients with endarteritis obliterans and nine patients with arteriosclerosis obliterans received physiotherapy with sinus-modulated current (80-100 Hz, modulation factor 50-75%, 20-35 mA, 2x 3 min/session, 10-12 sessions/course). All patients were aged 31-50 yr. Considerable improvement was achieved in 28 patients, improvement in 7, and no effect was seen in 3 cases. Improvement was defined by the alleviation or disappearance of pain and tremor, by improved gait, and by a reduction of ulceration.

- 5489 ASSESSMENT OF EFFECTIVENESS OF MUSCLE ELECTROSTIMULATION TO PREVENT HYPOKINESIA-INDUCED DISORDERS IN MAN. (Rus.) Cherapakhin, M. A. (No affiliation given); Kakurin, L. I.; Il'ina-Kakueva, E. I.; Fedorenko, G. T. *Kosm Biol Aviokosm Med* 11(2): 64-68; 1977.

The effectiveness of electrostimulation of the muscles of the shin, hip, abdomen and back, physical exercise, and a combination of both was studied in healthy men. The men were placed in a prone position (with the feet higher than the head by 4-6°) for 7 wk. Electrostimulation was achieved with 12 or 20 electrodes of a "Tonus-2" apparatus applied

1-2x, 25-30 min daily. Electrostimulation alone prevented the atrophy of the muscles and increased their tolerance to static load compared with non-stimulated controls, but it failed to prevent the impairment of cardiovascular system from lack of exercise (there was no significant difference in the increase of the heart rate after physical load between the stimulated and non-stimulated groups). Similar electrostimulation in conjunction with physical exercise prevented the deconditioning of the cardiovascular system (physical load caused only insignificant increase in the heart rate, and it increased the oxygen consumption per kg of body weight by 10% vs. a 12% reduction in the control). Further experiments will be necessary to determine the role of muscle electrostimulation in the prevention of hypokinesia-induced disorders.

5490 A STUDY OF ENVIRONMENTAL ELECTROMAGNETIC RADIATION LEVELS. (Eng.) Wang, J. C. (Applied Propagation Branch, Res. and Standards Div., Federal Communications Commission, Washington, DC 20554). 15 pp; December, 1977. [Technical Memorandum, Federal Communications Commission, Serial No. 4]. (9 refs)

The Federal Communications Commission's work in evaluating electromagnetic radiation levels is reviewed, and calculated and measured electromagnetic radiation levels in the vicinity of standard broadcast transmitters, frequency-modulated (FM) transmitters, television (TV) transmitters, microwave relay systems, devices using small linear antennas (walkie talkies), transmitting earth stations, and radars are presented. The calculated field strength for a 50-kW amplitude modulated broadcast transmitter varies from about 20 V/m at more than 200 m from the antenna to about 1,000 V/m at about 4 m from the antenna. For a 5,000-kW TV transmitter, the calculated field strength varies from about 4 V/m to 1,000 V/m at distances of about 200 m and 20 m, respectively, from the antenna. Power densities in the vicinity of a microwave relay antenna, which is 50 feet above ground, range from 0.043 mW/cm² at 0 m from the tower base to 0.0037 mW/cm² at 50 m from the tower base. For 5.625-GHz radar with an average power of 157 W and an antenna diameter of 1.82 m, the maximum near-field power density is 95.5 mW/cm²; the near field extends to approximately 24 m. In the far field, the power density decreases from 95.5 mW/cm² at 24 m to 47.75 mW/cm² at 48 m. For a large transmitting earth station operating at a frequency of 6 GHz with 6,744 W of power fed to a 30-m circular dish antenna, the maximum power density is 3.82 mW/cm², neglecting ground reflection. As the distance from the earth station antenna doubles, the power density decreases by 6 dB.

5491 BIOLOGIC EFFECTS OF ELECTRIC AND MAGNETIC FIELDS ASSOCIATED WITH PROPOSED PROJECT SEAFARER. (Eng.) Committee on Biosphere Effects of Extremely-Low-Frequency Radiation. (National Research Council, Washington, DC). 440 pp; [available through National Technical Information Services, Springfield, VA 22161, Document No., AD A-42515]. (5 refs)

A report on the possible biologic and ecologic effects of electric and magnetic fields associated with the Seafarer communication system proposed by the Navy is presented. The Seafarer is a system designed to provide communication with submarines and other military facilities from a single transmitting location in the United States. An operating frequency of 76 ± 4 Hz and maximal field intensities of about 0.1 V/m and 0.37 G directly over antenna cables are specified for the Seafarer system. For ground terminal areas, the maximal fields would be 15 V/m and 0.11 G. Potential effects of the Seafarer system are reviewed in terms of harm to plants, animals, and humans. It is concluded that with the exception of possible electrical shock hazards, the fields generated by the Seafarer system will not cause significant and adverse biologic disturbances. No specific biologic effects that will definitely result from exposure to the proposed Seafarer fields can be identified.

5492 ELECTRICALLY INDUCED LESIONS OF THE EYES. (Nor.) Hetland-Eriksen, J. (Ullevaal sykehus, Avdeling II, oye, Norway). *Tidsskr. Nor. Laegeforen* 97(23): 1157-1158; 1977. (7 refs)

Observations and studies on eye injuries caused by electric shock, short-circuit, and lightning are reviewed. Injury of the eyes is observed in about 5% of all accidents. The electric injuries of the eyes, as described in the literature, include perforation of the tarsus, hemorrhagic chemosis, keratitis, iridocyclitis, miosis, mydriasis, dislocation of the lens, electric cataract, detachment of the vitreous body, damages of the retina and choroid with edema, hemorrhage, pigmentation, and white spots. While retinal edema is temporary, pigmentation and white spots are permanent. Injury of the optic nerves, paresis of ocular muscles, nystagmus, and ptosis were also observed. Electric cataract develops usually 2-6 mo after the accident; regression is observed in few instances only. Electric cataract appears to be due to the injurious effect of the current on the capsule of the crystalline lens with subsequent permeability changes and alteration of the proteins of the lens fibers. There is no evidence of the cataract-inducing effect of electroshock therapy.

5493 MICROWAVE RADIATION NOT KNOWN TO BE TERATOGENIC (LETTER). (Eng.) Wheater, R. H. (American Medical Association Dept. Environmental, Public, and Occupational Health, Chicago, IL); Howen, G. G. *JAMA* 238(8): 895; 1977. (1 ref)

The possibility of teratogenic defects in the human fetus resulting from the use of a domestic microwave oven is discussed, and microwave-induced teratogenesis is reviewed. Experiments with microwave radiation on lower animals have demonstrated the likelihood of induction of chromosomal aberrations in the form of inhibited cell differentiation. Abnormalities were noted in the brain, eye, wing buds, and heart of chick embryos that were exposed to 20 mW/cm² for 280-300 min; there was also suppressed development of the hind limbs, tail, and allantois.

Anomalies in cellular development also were observed in the pupae of the "mealworm" beetle. However, there is no evidence that microwave radiation causes teratogenic effects in the human fetus under conditions that are likely to be encountered in the vicinity of domestic microwave ovens. An increased incidence of Down's syndrome was attributed in one study to occupational exposure of the father to radar; the statistical validity of the study, however, is questioned. With respect to the reproductive organs, microwave radiation is presumed to affect only the male gonads, resulting in a temporary and reversible reduction in testicular function (i.e., depressed sperm count).

- 5494 RADIO ENERGY HEALING--MEDICINE OR MYTH (LETTER TO EDITOR). (Eng.) Lightwood, R. (Queen Elizabeth Hosp., Edgbaston, Birmingham B15 2TH, England). *J Med Eng Tech* 1(4): 231; 1977. (7 refs)

A more thorough investigation into the therapeutic benefits of athermic pulsed radio frequency is urged. The author notes that a variety of ailments and injuries have improved under the influence of athermic radio frequency therapy including arthritis, soft tissue injuries, and burns and that no serious contraindications to treatment at a frequency of 27 MHz have been found.

- 5495 PRELIMINARY CLINICAL RESULTS OF COMBINED 433 MEGAHERTZ MICROWAVE THERAPY AND RADIATION THERAPY ON PATIENTS WITH ADVANCED CANCER. (Eng.) Hornback, N. B. (Dept. Radiation Oncology, Indiana Univ. Sch. Medicine, 1100 West Michigan St., Indianapolis, IN 46202); Shupe, R. E.; Shidnia, H.; Joe, B. T.; Sayoc, E.; Marshall, C. *Cancer* 40(6): 2854-2863; 1977. (52 refs)

The efficacy of combining microwave radiation with ionizing radiation for the treatment of 70 patients with far-advanced histologically proven malignancies refractory to standard forms of treatment was investigated. Each patient received 20 min of 433.92-MHz microwave radiation to the local tumor area immediately prior to receiving ionizing radiation at a total treatment dose that did not exceed a midline tumor dose of 3,000 rads in previously irradiated areas or 6,000 rads in previously unirradiated areas. Of 20 patients who completed the planned course of treatment and were followed for at least 9 mo, 90% experienced complete subjective relief of their symptoms and 10% received partial pain relief. Excellent local tumor regression was noted in the majority of patients, and 16 (80%) had complete regression of all tumor in the treated area. Of these 16 complete responders, 9 are alive 9-14 mo after treatment without evidence of disease. All patients tolerated the treatment well. The average rise in skin surface temperature after the 20 min of hyperthermic microwave treatment was 3.5°C. Although definite conclusions from this small nonrandomized study can not be drawn, the results confirm the impression that the effects of radiation are enhanced by microwave-induced hyperthermia.

- 5496 RAT LYMPHOCYTES IN CELL CULTURE EXPOSED TO 2450 MHZ (CW) MICROWAVE RADIATION. (Eng.) Hamrick, P. E. (Natl. Inst. Environmental Health Sciences, P.O. Box 12233, Research Triangle Park, NC 27709); Fox, S. S. *J Microwave Power* 12(2): 125-132; 1977. (28 refs)

The stimulation of cultured lymphocytes by microwave irradiation was investigated, and the uptake of tritiated thymidine by these cultures was compared with that of control cultures. Rat lymphocytes were exposed to continuous wave 2,450-MHz microwave radiation at intensities of 5, 10, and 20 mW/cm², and the corresponding rates of energy absorption were 0.7, 1.4, and 2.8 mW/g, respectively. When lymphocytes were exposed for 4, 24, or 44 hr to the above microwave intensities, with or without the addition of phytohemagglutinin, the transformation of lymphocytes into lymphoblasts was monitored by the addition of tritiated thymidine. No significant differences ($P < .05$) were observed in the uptake of tritiated thymidine between microwave-exposed cultures and control cultures. Based on these negative results and negative results reported by others, there is still considerable question as to whether microwaves can cause *in vitro* lymphocyte transformation or affect the response of lymphocytes to mitogens.

- 5497 EFFECTS OF 2.6-4.0 GHZ MICROWAVE RADIATION ON E-COLI B. (Eng.) Corelli, J. C. (Rensselaer Polytechnic Inst., Troy, NY 12181); Gutmann, R. J.; Kohazi, S.; Levy, J. *J Microwave Power* 12(2): 141-144; 1977. (8 refs)

The effects of 2.6-4.0-GHz microwave radiation on colony forming ability (CFA) and molecular structure of living *Escherichia coli* B bacterial cells in an aqueous suspension were investigated. Alterations in molecular structure were investigated by comparing the infrared spectrum of irradiated and unirradiated cell cultures. When cells were exposed for 10 hr to microwave radiation at absorbed power levels of about 19 mW (specific absorption rate of 20 W/kg), no microwave-induced effects were observed in terms of either CFA or molecular structure. It was concluded that microwave exposure at the above parameters affected neither viability nor the molecular integrity of this particular strain of *Escherichia coli*.

- 5498 BIOLOGICAL EFFECTS OF EXTREMELY LOW FREQUENCY ELECTRIC AND MAGNETIC FIELDS: A REVIEW. (Eng.) Marino, A. A. (Veterans Admin. Hosp., Syracuse, NY 13210); Becker, R. O. *Physiol Chem Phys* 9(2): 131-147; 1977. (122 refs)

The biologic effects of extremely low frequency (less than 100 Hz) electric and magnetic fields are reviewed. Acute electric field exposure is generally associated with effects on behavior, and there are reports linking such exposure with alterations in human reaction time. Chronic electric field exposure is generally found to affect growth, often producing retardation in development. For example, day-old chicks exposed to a non-uniform

maximum electric field of 35 V/cm exhibited depressed body weights, which were significantly lower than those of controls after 22 days of exposure to 45 Hz or 28 days of exposure to 60 Hz. There is also evidence that chronic exposure is a biologic stressor. Acute exposures to magnetic fields have been associated with the production of phosphenes, changes in reaction time and cognitive function in humans, and locomotor activity level changes in animals. Chronic exposure to low-strength magnetic fields is generally associated with some effect on growth or physiology. For example, significant increases in serum triglycerides have been observed 1-2 days after the exposure of human subjects to 1 G at 45 Hz for 1 day. Soviet epidemiologic studies have indicated the presence of neurologic or cardiovascular disorders in high-voltage switch-yard workers during, and shortly after, field exposure. Exposure to extremely low frequency electromagnetic fields has also been associated with changes in bird orientation and alteration in plant growth. Since neither extremely low frequency electric fields applied in air nor extremely low frequency magnetic fields up to at least 200 G can induce Joule heating in biologic tissue, the observed biologic effects are not thermal in origin.

5499 COMPARISON OF NATIVE AND MICROWAVE IRRADIATED DNA. (Eng.) Varma, M. M. (Bio-Environmental Engineering and Sciences Res. Lab., Sch. Engineering, Howard Univ., Washington, DC 20059); Traboulay, E. A. *Experientia* 33(12): 1649-1650; 1977. (9 refs)

Changes induced in testicular deoxyribonucleic acid (DNA) from Swiss mice irradiated (testes only) for 30 min with 1.7-GHz microwaves at a power density of 50 mW/cm² are reported. Although there was no difference in the DNA base ratios between irradiated mice and sham-irradiated control mice, the asymmetry ratio for irradiated mice was 1.6 compared with 1.32 for controls. A hyperchromic shift from a control value of 30% to a value of 24% in irradiated testicular DNA samples was observed along with a change in the melting temperature of DNA from a control value of 87°C to a value of 85°C for irradiated samples. These observations support the possibility that microwave radiation causes DNA strand separation, since changes in the optical density of DNA reflect a decrease in hydrogen bonding in the molecule. Consequently, it is suggested that a point mutation could occur if there were imprecise base pair matching.

5500 MICROWAVE REFLECTION AND TRANSMISSION MEASUREMENTS FOR PULMONARY DIAGNOSIS AND MONITORING. (Eng.) Pedersen, P. C. (Dept. Electrical Engineering, Drexel Univ., Philadelphia, PA 19104); Johnson, C. C.; Durney, C. H.; Bragg, D. G. *IEEE Trans Biomed Eng* 25(1): 40-48; 1978. (33 refs)

The feasibility of using low intensity microwave energy for early detection of lung diseases, such as, pulmonary edema and emphysema as well as for monitoring changes in total lung water was investigated. Two separate techniques were evaluated:

microwave reflection from the lung and microwave transmission through the lung. Single frequency reflection measurements at frequencies of 850 and 900 MHz in 20 healthy human subjects indicated that correlation of the measured reflection coefficient with lung water content is difficult, as the reflection coefficient is predominantly determined by the superficial tissue layers. However, reflection measurements on one dog at a frequency of 915 MHz and on another dog at 870 MHz indicate that the single-frequency reflection technique is feasible for monitoring applications. Experiments with three-layer phantom models of the human thorax provided direct evidence of detecting changes in total lung water with transmission measurements, and the agreement of experimental data with theoretical calculations demonstrated that absolute measurements of total lung water can be made in phantoms. A correlation of theoretic calculations for microwave transmission through the human chest with experimental data on normal human subjects exposed to frequencies swept over the range of 800 to about 950 MHz indicated that the transmission-line model may provide a sufficiently accurate representation of the transmission measurement process. Overall, it is concluded that low intensity microwave radiation may have value as a noninvasive diagnostic tool.

5501 USE OF MICROWAVE IRRADIATION TO PREVENT POSTMORTEM CATECHOLAMINE METABOLISM: EVIDENCE FOR TISSUE DISRUPTION ARTIFACT IN A DISCRETE REGION OF RAT BRAIN. (Eng.) Sharpless, N. S. (Dept. Psychiatry, Albert Einstein Coll. Medicine, Bronx, NY 10461); Brown, L. L. *Brain Res* 140(1): 171-176; 1978. (19 refs)

Microwave radiation was used to inactivate rat brain tissue enzymes in an attempt to obtain values for dopamine (DOP) and norepinephrine (NEP) levels consistent with true endogenous concentrations. In the septum of rats killed by a 6-sec exposure to 1.3 kW of focused microwave radiation at a frequency of 2,450 MHz, the mean DOP level (27.1 ± 2.6 ng/mg protein) was markedly and significantly higher than levels in the septum of rats killed by either decapitation (12.5 ± 1.0 ng/mg) or liquid nitrogen (14.0 ± 1.2 ng/mg). When the rats were killed 10 min before microwave irradiation, allowing time for postmortem metabolism, DOP levels in the septum (34.5 ± 3.9 ng/mg) were also increased. In contrast, the mean NEP level in the septum of rats killed by microwave radiation (7.2 ± 0.7 ng/mg) was significantly decreased with respect to that of rats killed by decapitation (11.7 ± 1.1 ng/mg) or by liquid nitrogen (11.4 ± 1.0 ng/mg). In the caudate, the mean DOP level for rats killed by microwave irradiation was significantly lower (86.4 ± 5.4 ng/mg) than that in rats killed by liquid nitrogen immersion (119.2 ± 10.8 ng/mg), while NEP levels were not different. Using a sensitive histochemical fluorescence method to determine the cellular localization of the catecholamines, evidence was found suggesting that the increased DOP levels in microwave-killed rats were not caused by rapid inactivation of catecholamine degradatory enzymes but

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rather by disruption of cell membranes and pressure-induced spread of DOP from the caudate to the adjacent septum. It is concluded that 1.3-kW microwave irradiation is not a suitable method to prepare brain tissue when regional catecholamine levels are being measured.

5502 BEHAVIORAL AND THERMAL EFFECTS OF MICROWAVE RADIATION AT RESONANT AND NONRESONANT WAVELENGTHS. (Eng.) D'Andrea, J. A. (Dept. Electrical Engineering, Univ. Utah, Salt Lake City, UT 84112); Gandhi, O. P.; Lords, J. L. *Radio Sci* 12 (6S): 251-256; 1977. (12 refs)

Behavioral and thermal effects of microwave radiation in Long-Evans rats were investigated at differing wavelengths and at various power densities. In one study five rats were trained to perform a lever-pressing task and were rewarded with food on a variable interval schedule of reinforcement. Rats were individually exposed in random order to 400, 500, 600, and 700-MHz continuous wave (CW) radiation at a power density of 20 mW/cm² with the long axis of the rat's body parallel to the vector of the electric field. Radiation at all wavelengths produced rises of body temperature and stoppage of lever pressing, with the averaged rise in body temperature being the greatest and work stoppage being most rapid during exposures at 600 MHz. In a second study, six rats were exposed in random order to 600-MHz CW radiation at power densities of 5, 7.5, 10, and 20 mW/cm² while performing the same lever-pressing task. Exposures at 10 and 20 mW/cm² resulted in work stoppage, while exposures at 5 and 7.5 mW/cm² did not. In addition, three of the rats were subsequently exposed, while responding, to 600-MHz pulsed radiation (1,000 pulses/sec, 3- or 30-μsec pulse durations at a peak power density of 170 mW/cm², averaged 0.51 and 5.1 mW/cm²). No work stoppage occurred in response to this pulsed radiation. Overall, the data show that the mature Long-Evans rat is resonant at a frequency of near 600 MHz and that work stoppage during short-term exposures to 600-MHz radiation occurs at a power density between 7.5 and 10 mW/cm².

5503 ARE THERE BIOLOGICAL AND PSYCHOLOGICAL EFFECTS DUE TO EXTRA HIGH VOLTAGE INSTALLATIONS? (Eng.) Atoian, G. E. (S&L Engineers affiliated with Sargent & Lundy, 6151 W. Century Blvd., Suite 920, Los Angeles, CA 90045). *IEEE Trans Power Apparatus Systems* 97(1): 8-18; 1978. (76 refs)

Laboratory and field investigations on the biologic and psychologic effects of extra high voltage (EHV) electric power installations are reviewed. The bulk of these investigations suggest that there is no conclusive evidence supporting the hypothesis that there might be significant long-term biologic and psychologic ill effects from EHV installations using the present commercial frequencies of 50-60 Hz. Russian investigators have reported that a number of switchyard workers have complained of an increase in excitability, headaches, drowsiness,

and other symptoms. However, these investigators report a maximum level of 27 kV/m in their 500-kv switchyards; whereas, the maximum field levels in the United States are below 9 kV/m. Also, the Soviets may have ignored or not reported other factors present in the switchyard, such as, ozone concentration, infrasonic acoustical noise, and gaseous pollutants that could cause similar effects. A review of various studies on the effects of EHV installations also reveals the need for an interdisciplinary approach to better understand and assess the limits of stress with regard to EHV fields.

5504 ENVIRONMENTAL CONSIDERATIONS CONCERNING THE BIOLOGICAL EFFECTS OF POWER FREQUENCY (50 OR 60 Hz) ELECTRIC FIELDS. (Eng.) Bridges, J. E. (IIT Res. Inst., 10 West 35th St., Chicago, IL). *IEEE Trans Power Apparatus Systems* 97(1): 19-32; 1978. (71 refs)

A comprehensive literature survey of studies on the biologic effects of 50-60 Hz high-voltage electric fields is presented to illustrate that conflicting findings may be due to the failure of investigators to consider other possible biologically significant environmental influences. Research results in Western Europe and America have failed to provide any evidence that human exposure to present levels of electric fields from high voltage overhead power lines, as normally encountered, has any harmful biologic effect. On the other hand, Russian and Spanish studies report complaints, such as, excitability, headaches, drowsiness, fatigue, and nausea among workers in high-voltage switchyards. However, the disparity of results may be attributed to differences between the environments found near high-voltage lines and within switchyards. High levels (104 dB) of 120-Hz sound have been measured in switchyards, and this noise could produce symptoms similar to those reported for switchyard workers. Other possible biologically significant environmental influences include repeated spark discharges and the chemical environment. A review of numerous other studies on the biologic effects of low-frequency electric fields reveals that the total environment has been similarly neglected.

5505 CHANGES IN CHROMOSOME MORPHOLOGY DUE TO MAGNETISM. (Eng.) Goswami, H. K. (Section Genetics, Sch. Biological Sciences, Bhopal Univ., Bhopal, India). *Cytologia (Tokyo)* 42(3/4): 639-644; 1977. (17 refs)

The effect of a strong uniform magnetic field (7,400 Oe) on the morphology of chromosomes in roots of *Pisum sativum* and *Allium sativum* was investigated. When the roots were exposed intermittently to the magnetic field for periods of 10-15 min, uncoiling of the genome and a piercing of the chromosome ends in the cell wall (probably the plasma membrane) were seen in the case of *Allium sativum*. Such cells did not show the signs of a nuclear membrane, indicating that the uncoiling of each chromosome started during late prophase and prometaphase. Splitting and separation of chromonemata were also

observed. The above observations resemble the usual features of prokaryotic cells, and these observations in a eukaryotic cell indicate the strong impact of the intermittent magnetic field on the chromosomes. The magnetic field also brought about an uncoiling of chromosomes at later stages of the cell cycle. In *Pisum sativum* root, long uncoiled chromosomes with parallel chromatids were drawn opposite to each other (pseudo-anaphase) due to magnetic field exposure. Chromosome breaks were frequently observed after magnetic field exposure. When exposed *Pisum sativum* cells were placed in a glucose solution, a small metacentric chromosome was often seen. This type of chromosome is not found in the karyotype of *Pisum sativum*, and its presence is assumed to be due to the magnetic exposure.

5506 HAZARDS OF NON-IONIZING RADIATIONS. (Eng.) Anonymous (No affiliation given). *Mech Eng* 100(1): 60-61; 1978. (3 refs)

Hazards of nonionizing radiation are discussed in relation to the increasing numbers of man-made sources of such radiation. There were about 250,000 microwave communication towers in 1972, and the average power output capabilities of 3-GHz microwave generators increased by a factor of about 10^6 since the end of World War II. About 2,000,000 people are treated annually with microwave diathermy. By 1980 about 5,000,000 microwave ovens are predicted to be in use. Also, solar power stations beaming energy to the earth via microwaves have been proposed. American investigators have found no conclusive evidence for hazardous effects of nonionizing radiation in man at levels of 100 mW/cm^2 , and there appear to be no effects at a tenfold lower level of 10 mW/cm^2 , which has been adopted in the United States and many other western countries for continuous exposure. However, the standard for safe continuous exposure in the USSR and other east-European countries is 0.01 mW/cm^2 because of the belief that microwaves have a direct nonthermal effect on the central nervous system that manifests itself in symptoms, such as, headaches, fatigue, general malaise, and neurasthenia. Even if low-level effects do exist, one cannot conclude that the mechanism is nonthermal merely because the average body temperature has not changed; local temperature rises could be produced by microwave absorption, and these local thermal effects may constitute the mechanism rather than a direct central nervous system effect.

5507 THEORETICAL CALCULATION OF FREQUENCIES AND THRESHOLDS OF MICROWAVE-INDUCED AUDITORY SIGNALS. (Eng.) Lin, J. C. (Dept. Electrical and Computer Engineering, Wayne State Univ., Detroit, MI 48202). *Radio Sci.* 12(6S): 237-242; 1977. (16 refs)

A thermoelastic model of microwave-induced auditory sensations was used to calculate the frequency and amplitude of the acoustic signals that are generated in laboratory animals and humans exposed to pulsed

(10 usec) microwaves. For laboratory animals exposed to 2,450-MHz rectangular microwave pulses at a peak absorption rate of 1 W/g , the predicted fundamental frequency, induced pressure, and displacement are 45 kHz, 4.08 dyne/cm^2 , and $2.16 \times 10^{-11} \text{ cm}$, respectively, for the guinea pig and 30 kHz, 3.69 dyne/cm^2 , and $1.51 \times 10^{-11} \text{ cm}$, respectively, for the cat. For humans exposed to 918 MHz rectangular microwave pulses at a peak absorption rate of 1 W/g , the predicted fundamental frequency, induced pressure, and displacement are 18 kHz, 9.61 dyne/cm^2 , and $9.34 \times 10^{-11} \text{ cm}$, respectively, for a human infant and 13 kHz, 6.82 dyne/cm^2 , and $3.97 \times 10^{-11} \text{ cm}$, respectively, for an adult human. The above data will be useful for threshold studies on exposure to microwave radiation and may also serve as a guide to the design of laboratory experiments aimed at resolving the exact mechanism of interaction in terms of the signal levels and frequency responses of test instruments.

5508 INHIBITION OF TUMOR GROWTH IN MICE BY MICROWAVE HYPERTERMIA, STREPTOLYSIN S AND COLCEMIDE. (Eng.) Szmagelski, S. (Center for Radiobiology and Radioprotection, 00-909 Warsaw, Poland); Pulverer, G.; Hryniwicz, W.; Janiak, M. *Radio Sci.* 12(6S): 185-189; 1977. (35 refs)

The effect of whole-body microwave hyperthermia on tumor growth in mice was investigated. CFW mice with transplanted Sarcoma 180 were irradiated with 3-GHz microwaves at a power density of 40 mW/cm^2 for 2 hr/day from day 1-14 after tumor transplantation. The irradiation resulted in an increase of 3-4°C in rectal temperature. Some of these irradiated animals received daily intraperitoneal injections of Colcemide (1 mg/kg) and/or purified Streptolysin S (0.5 mg/kg). An examination of dissected tumors on day 14 after transplantation revealed that microwave hyperthermia resulted in about a 40% reduction in the tumor mass. This reduction was enhanced when microwave hyperthermia was combined with Colcemide and/or Streptolysin S; the tumor mass was reduced by about 70% when all three agents were combined. Inhibition of tumor growth was accompanied by reduced uptake of tritiated thymidine and tritiated uridine into the tumorous tissues. It is concluded that whole body microwave radiation, even if repeated daily for 2 wk, is a safe and noninvasive treatment that leads to inhibition of tumor growth and that this inhibition can be enhanced when microwave hyperthermia is combined with nonspecific bacterial products and agents that influence the cell cycle.

5509 HYPERACTIVITY AND DISRUPTION OF OPERANT BEHAVIOR IN RATS AFTER MULTIPLE EXPOSURES TO MICROWAVE RADIATION. (Eng.) Mitchell, D. S. (Southwest Res. Inst., 8500 Culebra Road, San Antonio, TX 78284); Switzer, W. G.; Bronaugh, E. L. *Radio Sci.* 12(6S): 263-271; 1977. (18 refs)

The effects of chronic low-intensity continuous wave microwave irradiation on one innate behavior (locomotor activity) and two learned behaviors

(discriminative operant reward conditioning and Sidman avoidance) in female Sprague-Dawley albino rats were investigated. Exposure to 2.45-GHz radiation at an averaged specific absorption rate of 2.3 mW/g produced a pronounced increase in locomotor activity relative to both preirradiation baseline values and to activity levels of sham-irradiated controls. Microwave irradiation also disrupted differential responding during tests of an appetitively reinforced operant behavior. Irradiation had no differential effects on the performance of a Sidman avoidance response. The observed effects emerged almost immediately after the initiation of microwave irradiation and persisted throughout the course of a 22-wk sequence of exposures to radiation. Periodic rectal temperature measurements revealed no indication of whole-body temperature elevation in irradiated rats. The observed behavioral effects are consistent with a general activation hypothesis and suggest microwave-induced alterations in the function of the central nervous system.

5510 PROGRESS IN CLOSTRIDIAL ONCOLYSIS AND DIAGNOSIS. (Eng.) Gericke, D. (Hoechst AG, Frankfurt/M., W. Germany). *Rev Can Biol* 36 (3):195-203; 1977. (17 refs)

Tumor-bearing animals were conditioned with short-term microwave-induced hyperthermia at various times before the administration of *Clostridium oncolyticum*, strain *butyricum* (M 55) to enhance the oncolytic action of the *Clostridia* strain. Ehrlich carcinoma that were subjected to hyperthermia 12 hr prior to *Clostridia* administration showed statistically significant increases in the degree of oncolysis and the percentage of animals with oncolysis. Oncolysis was observed in $61.3 \pm 2.9\%$ of the animals receiving this combined treatment compared with $27.6 \pm 1.5\%$ of animals receiving *Clostridia* alone and 0% for animals receiving hyperthermia alone or no treatment (controls). The tumor volumes measured in the above experimental groups were 1.27 ± 0.10 , 2.36 ± 0.07 , 2.04 ± 0.14 , and 2.85 ± 0.11 ml, respectively. The enhancement of the oncolytic action of *Clostridia* by pretreatment of tumors with hyperthermia was also observed in methylcholanthrene-induced fibrosarcoma and in Harding-Passey melanoma. Hyperthermia plus *Clostridia* treatment in the former tumor resulted in oncolysis in $22.4 \pm 3.17\%$ of the animals treated compared with $1.16 \pm 0.36\%$ for animals treated with *Clostridia* alone and 0% for animals treated with hyperthermia alone and untreated controls. The tumor volumes measured in the above experimental groups were 1.85 ± 0.19 , 2.29 ± 0.15 , 2.07 ± 0.51 , and 2.48 ± 0.18 ml, respectively. Similar treatments in Harding-Passey melanoma resulted in tumor volumes of 1.614 ± 0.13 , 2.487 ± 0.10 , 3.231 ± 0.20 , and 2.606 ± 0.13 ml, respectively, and oncolysis rates of 89.41 ± 3.03 , 14.77 ± 2.42 , 0, and 0%, respectively. A dose-dependent effect of hyperthermia was demonstrated. After 60 sec of microwave-induced hyperthermia, the number of completed lysed cells in the Harding-Passey melanoma was only 30% compared with 84% after a 180-sec treatment. It was also observed that the optimum

interval between hyperthermia treatment and *Clostridia* administration was specific to the type of tumor treated (data not indicated).

5511 CHANGES IN THE SHAPE OF HUMAN ERYTHROCYTES UNDER THE INFLUENCE OF A STATIC HOMOGENEOUS MAGNETIC FIELD. (Eng.) Leitmannova, A. (Humboldt-Universitat zu Berlin, Sektion Biologie, Bereich Biophysik und Sektion Chemie, Bereich Magnetochemie, 104 Berlin, W. Germany); Stosser, R.; Glaser, R. *Acta Biol Med Ger* 36(5/6): 931-934; 1977. (5 refs)

Changes in the shape of human erythrocytes exposed to a static homogeneous magnetic field are reported. Over a magnetic field strength range of 1-11.1 kOe, a transformation of echinocytes into discocytes, stomatocytes, and hemolyzing cells occurred. The number of transformed echinocytes depended on both the exposure time and on the magnetic field strength, and the ratio of newly formed discocytes to newly formed stomatocytes was dependent on the field strength. The transformation effects observed can be divided into three ranges of magnetic field strength. The first range extends from about 1-4.6 kOe, with a maximum occurring at 2.5 kOe. This range is typical for fields causing phase transitions in fluid-crystalline systems and analogous structured biologic model membranes. In the second range (4.6-8.9 kOe), there is a minimum in the number of erythrocyte transformations. The third range (8.9-11.1 kOe) is characterized by a strong increase in the number of transformed cells. In this range the field begins mainly to influence macromolecular components with a large anisotropy of the magnetic susceptibility. Based on the field strength and time interval required for echinocyte transformation, it is assumed that it was not the primary influence of the magnetic field on the erythrocytes that was observed in these experiments. Rather, the shape of human erythrocytes must be regarded as a metastable state, which is determined by the surface, volume, and plane inhomogeneities of certain mechanistic membrane parameters, such as, bending elasticity and viscosity.

5512 OPERANT BEHAVIOR AND COLONIC TEMPERATURE OF SQUIRREL MONKEYS (*SAIMIRI SCIUREUS*) DURING MICROWAVE IRRADIATION. (Eng.) de Lorge, J. O. (Naval Aerospace Medical Res. Lab., Naval Air Station, Pensacola, FL 32508). 33 pp.; 1977. [available through National Technical Information Services, Springfield, VA 22161, Document No. AD A043706]. (6 refs)

Squirrel monkeys (*Saimiri sciureus*) on a vigilance task were exposed for 30 or 60 min to various power levels of 2,450-MHz microwaves amplitude modulated at 120 Hz to investigate the effect of this radiation on their behavior. Vigilance task behavior was disrupted by 30- or 60-min exposures to 50 mW/cm² and higher power densities. This disruption increased with increases in power density. Under both durations of exposure, behavior was not consistently perturbed until colonic temperatures

exceeded 1°C. Colonic temperatures regularly increased beginning at a power density of 10 mW/cm² and were related in a nonlinear fashion to the power density, with a marked acceleration occurring between 40 and 50 mW/cm². The observed behavioral changes were concluded to be directly related to hyperthermia in the squirrel monkey, since only in those cases where colonic temperature increases exceeded 1°C was behavior consistently affected. The effects of the microwave radiation were probably temporary because the monkeys generally recovered previous response rates when the exposure conditions were removed.

- 5513 FIXED INTERVAL BEHAVIOR OF RATS EXPOSED TO MICROWAVES AT LOW POWER DENSITIES. (Eng.) Sanza, J. N. (Naval Aerospace Medical Res. Lab., Naval Air Station, Pensacola, FL 32508); de Lorge, J. *Radio Sci.* 12(6S): 273-277; 1977. (6 refs)

Rats in a response chamber were exposed for 60 min to 2.45-GHz microwaves (100% amplitude modulated at 120 Hz) at averaged power densities of 8.8, 18.4, and 37.5 mW/cm² of incident radiation to investigate the effects of this radiation on their behavior. Lever pressing by four Sprague-Dawley rats was reinforced by food pellets on a fixed-interval 50-sec schedule and produced high rates of responding in two rats and low responding rates in two other rats. Radiation at 37.5 mW/cm² disrupted the lever response of the two rats that responded at high rates during baseline studies. Radiation at the two lowest power densities had no observable effect on the rate of responding. No effects on the rate of lever pressing were observed at any of the power densities in the two rats that responded at low rates during baseline studies. However, ambulatory activity of all rats decreased during irradiation at 18.4 and 37.5 mW/cm². This decrease was associated with a tendency of the rats to remain in areas of the response chamber with lower power densities of radiation. These results are believed to be due to an interaction between higher metabolic rates in the more frequently responding rats and exogenous heating by microwave radiation.

- 5514 ECONOMIC AND ENVIRONMENTAL COSTS OF SATELLITE SOLAR POWER. (Eng.) Glaser, P. (Arthur D. Little, Inc., Cambridge, MA). *Mech Eng* 100(1): 32-37; 1978. (10 refs)

Possible biologic and environmental effects associated with microwave beams from satellite solar power stations are reviewed. Projected solar satellites would beam microwave energy to a 52 km² receiving antenna on earth for conversion into electric power transmission grids. Such satellites will incorporate several fail-safe features to assure control of the microwave beam pointing and instantaneous shutoff of power to the microwave generators. Failure of the microwave beam-pointing system would not result in exceeding the international standards for microwave exposure. Predictions, analyses, and measurements of the microwave-induced biologic effects from solar satellites

will be an essential part of the satellite development program. Possible effects on birds flying through the microwave beam will have to be established along with the effects of microwave exposure on aircraft flying through the beam. The shielding effects of the metal fuselage of an aircraft and the very short time of flight through the beam make it unlikely that significant human exposure will occur. Scattering of the microwave beam by rain or hail is not expected to significantly increase sidelobe levels or broaden the main microwave beam.

- 5515 INDUCED EM FIELDS INSIDE HUMAN BODIES IRRADIATED BY EM WAVES OF UP TO 500 MHZ. (Eng.) Chen, K.-M. (Dept. Electrical Engineering and Systems Science, Michigan State Univ., East Lansing, MI 48824); Guru, B. S. *J Microwave Power* 12(2): 173-183; 1977. (15 refs)

The internal electromagnetic (EM) field and the specific absorption rate (SAR) of EM energy induced inside human bodies by EM waves of 30-500 MHz are theoretically quantified based on a tensor integral equation method. Numeric results for a realistic model of a man with a height of 177 cm irradiated by EM fields of various frequencies and of vertical and horizontal polarizations indicate that the magnitude and distribution of the SARs in a body of fixed dimensions are strongly dependent on the frequency and polarization of the incident EM wave. Hot spots are generally more often created in regions with small cross-sectional areas, such as, the neck, arms, and thigh-leg regions. Greatly enhanced SARs are predicted in regions of low conductivity and permittivity, such as, the lungs, where a vertically polarized EM wave of 80 MHz is predicted to result in an SAR of 117 mW/m³ compared with a predicted value of 31.4 mW/m² for the same region of a homogeneous body. A comparison of the above theoretic results with previously reported experimental results indicates that the theory agrees quite well with experimental data over regions of high power absorption. The above theoretic results are considered to be more accurate than previously reported results based on a simpler homogeneous model.

- 5516 POSTMASTECTOMY PATIENT WITH SENSITIVITY TO MICROWAVE OVEN IN OPERATIVE AREA (LETTER TO EDITOR). (Eng.) Michaelson, S. M. (Univ. Rochester Sch. Medicine and Dentistry, Rochester, NY); Appleton, B. *JAMA* 239(4): 350; 1978. (0 refs)

The report of a postmastectomy patient with sensitivity in the operative area to a microwave oven is discussed. A 52-yr-old woman who had a right-sided mastectomy reported that after turning on a recently purchased microwave oven she experienced a strange sensation in the operative area as she approached the oven. Shielding the operative area with an aluminum pan or foil seemed to prevent the sensation. The mastectomy had been performed using nonmetallic suture, and healing was complete. In view of the fact that the microwave oven was recently purchased and that its emission was prob-

ably well below the emission standard of 5 mW/cm² set by HEW, there is no possibility that the patient could have sensed the microwave radiation, since probable exposure levels were certainly three and probably four times below threshold levels for sensation. However, if the oven is leaking at a noteworthy level, the microwave energy impinging on the patient's operated area could possibly be sensed as heat, but the likelihood that a closed microwave oven would leak that much microwave energy is extremely small. It is recommended that a local or state health physics agency be contacted to measure the leakage of the oven.

- 5517 INCREASE IN THE FREQUENCY OF Fc RECEPTOR (FcR) BEARING CELLS IN THE MOUSE SPLEEN FOLLOWING A SINGLE EXPOSURE OF MICE TO 2450 MHZ MICROWAVES. (Eng.) Wiktor-Jedrzejczak, W. (Div. Cellular Immunology, Dept. Clinical and Experimental Immunology, Naval Medical Res. Inst., Bethesda, MD 20014); Ahmed, A.; Czerski, P.; Leach, W. M.; Sell, K. W. *Biomedicine [Express]* 27(7): 250-252; 1977. (11 refs)

Changes in the absolute frequency of cells from different lymphoid populations in the spleen of CBA/J male mice exposed for 30 min to 2,450-MHz microwave radiation at an average absorbed dose of 13.7 ± 1.2 mW/g and in sham-exposed mice were investigated. There was a significant ($p < 0.01$) increase in the frequency of spleen cells bearing a receptor for the Fc portion of the immunoglobulin molecule (FcR) 7 days after microwave exposure; the percentage of FcR-positive cells in irradiated mice was $44.8 \pm 1.5\%$ compared with a control value of $36.5 \pm 1.6\%$. Simultaneously, a significant ($p < 0.05$) increase in the proportion of complement receptor-positive spleen cells was observed ($30.4 \pm 1.8\%$ for irradiated mice versus $23.7 \pm 0.8\%$ for controls). The frequencies of theta-positive and immunoglobulin-positive cells and the total number of spleen cells remained unchanged after microwave irradiation. The proportion of immunoglobulin-positive, FcR-positive cells in the spleens of microwave-exposed mice ($29.0 \pm 0.7\%$) was significantly higher ($p < 0.01$) than that in the spleens of control mice ($21.2 \pm 0.9\%$). This difference quantitatively corresponded to the increase in total FcR-positive cells, suggesting that the increase in FcR-positive cells was due to a selective increase in immunoglobulin-positive, FcR-positive cells. The above results confirm the preferential action of small doses of microwaves on B lymphoid cells in the mouse.

- 5518 THE EFFECT OF SEQUENCE AND TIME INTERVALS OF COMBINED HYPERTHERMIA AND RADIATION TREATMENT OF A SOLID MOUSE MAMMARY ADENOCARCINOMA IN VIVO (LETTER TO EDITOR). (Eng.) Overgaard, J. (Cancer Res. Inst. and The Radium Center, DK-8000 Aarhus, Denmark). *Br J Radiol* 50(598): 763-765; 1977. (11 refs)

An isologous moderately differentiated mouse mammary adenocarcinoma was treated with a combination of 27.12 MHz diathermy (42.5°C for 30 min) and 250 kv x-rays (800 rad). The heat was applied either before

or after radiation using differing time intervals. For tumors treated simultaneously, the radiation was applied at the midpoint of the 30-min heating period. When heat was applied before irradiation with between-treatment intervals of 4, 8, 12, 24, and 48 hr, the cure rates obtained were 0/8, 2/8, 2/9, 0/9, and 1/5, respectively. The simultaneous application of hyperthermia and radiation resulted in a cure rate of 1/7. When heat was applied after irradiation with between-treatment intervals of 4, 8, 12, 24 and 48 hr, the cure rates were 1/6, 2/11, 2/9, 1/8, and 3/7, respectively. The application of heat alone (42.5°C for 30 min) or radiation alone (800 rad) resulted in cure rates of 0/10 in each instance. The differences between the various combined treatment schedules were not statistically significant. These results demonstrate that the action of hyperthermia when combined with radiation *in vivo* is not necessarily due to a radiosensitizing effect. Examination of a section of tumor 48 hr after treatment at 42.5°C for 30 min revealed that this heat was sufficient to produce necrosis in the center of the tumor, leaving only a few peripheral cells viable.

- 5519 EVIDENCE FOR NON-THERMAL EXCITATION OF ENERGY LEVELS IN ACTIVE BIOLOGICAL SYSTEMS. (Eng.) Webb, S. J. (Dept. Physics, Univ. South Florida, Tampa, FL); Stoneham, M. E.; Froehlich, H. *Phys Lett* 63A(3): 407-408; 1977. (7 refs)

The ratio (R) of the intensities of anti-Stokes and Stokes Raman shift lines of 125 cm^{-1} and 118 cm^{-1} of active *Escherichia coli* B (glucose nutrient) was measured to investigate if the Raman lines represent excitations beyond thermal equilibrium. Spectra taken 40, 50, and 60 min after the beginning of incubation at a temperature above 25°C indicated an R value of 1.01 ± 0.10 for 118 cm^{-1} and 0.93 ± 0.13 for 125 cm^{-1} . These experimental values are far above the expected R value of about 0.55 for an oscillating system in thermal equilibrium, indicating that this system is excited strongly above thermal excitation. These excitations should be interpreted as arising from certain activities of the cell that change with its age.

- 5520 STIMULATION OF DOG THYROID BY LOCAL APPLICATION OF HIGH INTENSITY MICROWAVES. (Eng.) Magin, R. L. (Lab. Chemical Pharmacology, Natl. Cancer Inst., Bldg. 37, Room 5A13, Bethesda, MD 20014); Lu, S-T.; Michaelson, S. M. *Am J Physiol* 233(5): E363-E368; 1977. (25 refs)

The effects of local irradiation with 2.45-GHz continuous wave microwaves on thyroxine release in the dog thyroid gland were studied. Both of the paired thyroid glands of the dog were surgically exposed, and their caudal veins were cannulated. The first hour after cannulation was used as an equilibrium period to establish a base-line thyroxine release rate for each gland. During the subsequent 2 hr, one gland was locally heated with microwaves to temperatures of 39 , 41 , or 45°C , while the contralateral gland was used as a control. The specific microwave absorption rates in the microwave-exposed

thyroid gland at the above temperatures were 58 ± 24 , 131 ± 44 , and 190 ± 45 W/kg, respectively; the corresponding incident power densities at the surface of the exposed gland were 72 ± 29 , 162 ± 54 , and 236 ± 55 mW/cm², respectively. The thyroxine release rate of the irradiated glands was increased during the 2-hr exposure period to 200, 350, and 1,000% of the equilibration period means for the three temperatures studied. Blood flow was increased to 140 and 170% of the equilibration period means in glands heated to 41 and 45°C, respectively. Contralateral control glands and sham-exposed glands maintained a constant thyroxine release rate. These results demonstrate that local microwave heating of the thyroid gland can stimulate both thyroid gland blood flow and thyroxine release.

5521 CONSIDERATIONS ON THE MEASUREMENT OF THE ELECTRICAL CHARACTERISTICS OF MICROORGANISMS. (Ita.) Tiberio, U. (Universita di Pisa, Pisa, Italy). *Alta Frequenza* 46(7): 313-318; 1977. (11 refs)

Problems of the measurement of the electrical characteristics of microorganisms suspended in culture medium in alternating and direct current fields are discussed, with special reference to the use of electrical and electromagnetic fields for sterilization.

5522 MICROWAVE FIXATION OF BRAIN TISSUE AS A NEUROCHEMICAL TECHNIQUE—A REVIEW. (Eng.) Merritt, J. H. (Radiation Physics Branch, Radiation Sciences Div., USAF Sch. Aerospace Medicine, Brooks AFB, TX 78235); Frazer, J. W. *Microwave Power* 12(2): 133-139; 1977. (36 refs)

Neurochemical studies, which have used microwave-fixation techniques for the inactivation of brain enzymes are reviewed, and the suitability of these techniques is discussed. The rapid enzyme inactivation by microwave fixation of brain tissue prevents postmortem changes and permits the measurement of neurochemicals, such as, acetylcholine, at concentrations close to those obtained *in vivo*. It is well established that acetylcholine content in whole brain fixed by microwave radiation is higher than in the brain of an animal killed by decapitation or cervical dislocation. Freeze-blowing techniques arrest enzymic activity, but they destroy the brain architecture, making dissection impossible and allowing enzymic activity to be restored, if the tissue thaws. Early applications of microwave fixation were slow (10-20 sec) and post-mortem changes occurred; however, recently several devices have been described that are designed to focus microwave power on the heads of small animals through a waveguide. Brain temperatures of 90°C can be achieved in as little as 300 msec. Enzyme systems such as adenyl cyclase, phosphodiesterase, cholinesterase, choline acetyltransferase, and reduced nicotinamide adenine dinucleotide-diaphorase are completely and irreversibly inactivated at this temperature. Microwave tissue-fixation also permits easy dissection of the fixed brain into discrete parts.

5523 MICROWAVE IRRADIATION: A NEW RAPID TECHNIQUE FOR SEPARATING EPIDERMAL TISSUE FROM MOUSE SKIN PRESERVING RNA, DNA, PROTEIN, AND PHORBOL ESTER-INDUCED ORNITHINE DECARBOXYLASE LEVELS. (Eng.) Mufson, R. A. (McArdle Lab. for Cancer Res., Univ. Wisconsin, Madison, WI 53706); De Young, L. M.; Boutwell, R. K. *J Invest Dermatol* 69(6): 547-550; 1977. (20 refs)

A microwave separation procedure and its applications are described. The exposure of mouse skin (CD-1 mice) to 2,450-MHz microwave radiation for 10 sec allowed for the separation of the epidermis from the dermis by gentle scraping of the skin with a scalpel. At the end of the irradiation period, the subcutaneous temperature was 55°C. Histologically, the microwave-irradiated skin resembled skin exposed to an established heat separation procedure (immersion in 55°C water followed by immersion in 0-4°C water). The recoveries of deoxyribonucleic acid, ribonucleic acid and protein extracted from epidermis harvested by microwave separation were 22.4 ± 3.5 , 13.1 ± 2.6 , and 422 ± 76.0 µg/cm², respectively; these values were not significantly different from those observed in epidermis harvested by conventional heat separation (20.6 ± 2.2 , 13.0 ± 1.0 , and 390 ± 40.8 µg/cm², respectively). Phorbol ester-induced ornithine decarboxylase levels in irradiated and heat-separated epidermis were comparable and not significantly different, being 6.1 ± 1.3 and 3.8 ± 0.4 nmoles of carbon dioxide/mg protein/30 min, respectively. The reduced amount of manipulation and the short irradiation time required by the microwave separation technique can result in a considerable time savings.

5524 BIOLOGICAL EFFECTS. (Nor.) Lein, M. (No affiliation given). *Teknisk Ukeblad* 124(48): 3; 1977. (0 refs)

Current findings on the biological effects of microwave radiation are reported. There has been reported a higher incidence of memory impairment, motor co-ordination disturbances, and cancer among persons working in a Chicago business district with high microwave energy levels. The cancer incidence of U.S. Embassy personnel in Moscow is believed to be higher than that of the staff of other U.S. embassies because of the microwave bombardment of the U.S. embassy by the Russians. The maximum permissible microwave exposure in the USSR has been set at 10 µW on the basis of the biological effects of microwaves. Further reduction of this standard is planned.

5525 COUPLING BETWEEN SMALL THIN-WIRE ANTENNAS AND A BIOLOGICAL BODY. (Eng.) Nyquist, D. P. (Dept. Electrical Engineering and Systems Science, Michigan State Univ., East Lansing, MI 48824); Chen, K-M.; Guru, G. S. *IEEE Trans Antennas Propagation* 25(6): 863-866; 1977. (5 refs)

A theoretic analysis of coupling between the electromagnetic (EM) field of a small thin-wire antenna excited at a frequency of 50 MHz and an adjacent finite biologic body (140 cm in height and 40 cm in diameter) selected to model the torso of a human

radio operator is presented. Short antennas excited at 50 MHz are typical of those used for man-pack radio sets. It is shown that the electric field induced in a finite biologic body by a nonuniform EM field of an adjacent antenna is very sensitive to the relative antenna-body location. Potentially hazardous induced fields may occur at antenna input powers as small as 20 W for certain practical antenna locations. Proximity effects of the body on the antenna input impedance are very strong, and the ratio of dissipated to input power depends strongly on antenna location. The body acts as a reflector in its proximity effects on the antenna radiation field and produces some directivity in the H-plane of a short dipole.

5526 SELECTIVE RADIOFREQUENCY HEATING OF FERRO-SILICONE OCCLUDED TISSUE: A PRELIMINARY REPORT. (Eng.) Rand, R. W. (UCLA Sch. Medicine, Dept. Surgery, Div. Neurosurgery, Los Angeles, CA 90024); Snyder, M.; Elliott, D.; Snow, H. *Bull Los Angeles Neurol Soc* 41(4): 154-159; 1977. (29 refs)

Selective radiofrequency heating of ferrosilicone-occluded tissue was investigated in relation to its possible role in the hyperthermic treatment of cancer. Glidden B-233 iron powder in a ferrosilicone mixture was injected into the renal arterial bed of dogs, a model of vascular tumors with a selective blood supply. Once the mixture vulcanized, the animals were sacrificed, and the kidneys removed. Injected kidney sections exposed to 500 kHz radiation sustained a heating rate of 8 C/min and plateaued in 5 min. Control sectioned kidneys sustained a heating rate of 2 C/min and also plateaued in 5 min. When tested at a frequency of 20 kHz, control unsectioned kidneys underwent no measurable heating; whereas, injected unsectioned kidneys consistently sustained a heating rate of 10 C/min in the cortex and 12 C/min in the medulla and then plateaued in 5 min.

5527 EFFECT OF A PULSED ELECTRIC CURRENT ON THE COURSE OF REPARATIVE OSTEOGENESIS. (Eng.) Landa, V. A. (Lab. Biophysics, N. N. Priorov Central Scientific-Res. Inst. Traumatology and Orthopedics, Ministry Health USSR, Moscow, USSR); Polyakov, A. N.; Baranov, V. K. *Bull Exp Biol Med* 83(5): 700-702; 1977. (12 refs)

The effect of pulsed electric current on reparative osteogenesis in rabbits was studied. A portion of the middle third of the radial diaphysis measuring 0.5 cm was resected, and a platinum electrode was inserted perpendicularly to the long axis of the bone into holes drilled into each of the two bone fragments. Another electrode was placed in the gap between the fragments. A pulsed electric current with an optimal strength ranging from 6-15 μ A, a pulse duration of 1 sec, and a between-pulse interval of 4 sec was applied to the electrodes five times/wk for 3 wk after bone resection. Osteogenesis was stimulated in bone treated with electric current, with the stimulating effect being manifested by a larger quantity of newly-formed bone and a

smaller quantity of cartilage and fibrous tissue in the callus than was observed in control animals. The degree of mineralization of newly-formed bone microstructures was comparable in experimental and control animals. It is concluded that by applying a pulsed electric current during reparative bone regeneration, osteogenesis can be stimulated and made to predominate over fibrogenesis and chondrogenesis.

5528 US ARMY TEST AND EVALUATION COMMAND-TEST OPERATING PROCEDURE: ELECTROMAGNETIC RADIATION EFFECTS AND/OR HAZARDS TEST. (Eng.) U. S. Army Test and Evaluation Command (U.S. Army White Sands Missile Range, ATTN: STEWS-TE, White Sands Missile Range, NM 88002). 16 pp.; 1976. [available through National Technical Information Services, Springfield, VA 22161, Document No. AD A039703]. (0 refs)

Procedures for instrumenting and testing United States Army materiel containing electric initiators and/or electronic components to determine the effect of an electromagnetic environment on the operation and/or safety of the materiel are presented. The testing facilities are capable of generating test fields of 100-200 V/m over a frequency range of 100 kHz through 18 GHz. At each test frequency, for each configuration of the specimen in its stockpile-to-target sequence, and from all aspect angles, the test specimen is exposed to continuous wave electromagnetic radiation environments starting at the frequency at which the maximum dimension of the tested item is a quarter wavelength. The field intensity of the environment is gradually increased until any of the following conditions are met: the criteria field intensity is reached; an adverse effect is indicated on recording instrumentation; the capability of the test facility is reached. If the test specimen may be exposed to modulated environments, the tests should be performed using amplitude modulated, frequency modulated, and pulse modulated electromagnetic radiation.

5529 HYGIENIC PROBLEMS OF THE INDUSTRIAL USE OF NON-IONIZING RADIATION. (Ita.) Grandolfo, M. (Laboratori di Fisica, Istituto Superiore di Sanita, Italy); Guidoni, L.; Viti, V. *Ann Ist Super Sanita* 12(4): 241-247; 1976. (31 refs)

General hygienic problems of microwave, laser, infrared, and ultraviolet radiations are reviewed. The biologic effects of radiofrequency radiation are determined not only by mean field intensity but also by intensity peaks in cases of intermittent radiation. Apart from the direct thermal effect, the effects of radiofrequency radiation include functional disturbances of the central nervous system (neuralgia, eye pain, vertigo, insomnia, somnolence during daytime), reduced libido and potency in men, menstrual disorders, and increased incidence of abortion in women. Young women are more sensitive to radiofrequency radiation than older ones. The maximum permissible exposure levels are 10 mW/cm² in the frequency range of 10-100,000

MHz in the USA; in the USSR 1 mW/cm² is the permissible level for a daily exposure of 10-15 min, 0.1 mW/cm² for 2-3 hr/day, and 0.01 mW/cm² for 8 hr/day.

- 5530 BIOLOGICAL AND MEDICAL PROBLEMS CAUSED BY UHF RADAR WAVES. I. PHYSICAL PRINCIPLES. BIOLOGICAL PROBLEMS (EXPERIMENTS IN ANIMALS). (Fre.) Delahaye, R. (Ecole d'application du Service de Sante pour l'Armee de l'air, Paris, France). *Radio-protection* 12(3): 199-216; 1977. (0 refs)

The physical principles and experiments on the biologic effects of radar waves are reviewed. Radar waves have thermal or unspecific and nonthermal or specific effects on biologic organisms. The thermal effect is due to the absorption of the energy by the tissues. It is possible to generate lethal hyperthermia in animals by whole-body or brain irradiation, which fails to cause any morphologic changes. The depth of penetration of radar waves into the body is estimated at 1/10 of their wavelength. The testicles and crystalline lens are especially sensitive to hyperthermia generated by radar waves. Minimal energy density capable of producing opacification of the crystalline lens of the rabbit is 0.59 W/cm² for 5 min exposure or 0.29 W/cm² for 90 min exposure at a frequency of 2,500 MHz. Various experiments have revealed specific effects, such as, changes in the ratio of excitation to inhibition of the cerebral cortex; changes in biochemistry (cholinesterase, nucleic acid, and amino acid levels); changes in blood pressure (tachycardia) and heart rate; hyperplasia of the reticuloendothelial system of the spleen, liver, and thymus of animals; and lymphocytosis. Radar treatment has a protective effect against x-rays in mice and against gamma rays (24,000 R and higher) in bacteria. The specific effects of radar waves are currently explained with various hypotheses (pearl chain effect, electrical excitation of biological membranes, macromolecular resonance, and Osipov's microthermal theory).

- 5531 SELECTIVE LOCAL HYPERHERMIA OF TUMOR TISSUE. HOMOGENIZED ENERGY SUPPLY TO DEEP-SEATED TISSUES BY HIGH-ENERGY DECAMETER WAVE COIL SECTION PLUS DUAL SYSTEM RASTER MOTION. (Ger.) von Ardenne, M. (Forschungsinstitut Manfred von Ardenne, Zeppelinstr. 7, DDR-8051 Dresden, E. Germany); von Ardenne, Th.; Boehme, W. G.; Reitnauer, P. G. *Arch Gesamtsch Forstw* 47(6): 487-523; 1977. (41 refs)

The achievement of selective local hyperthermia of deep-seated tumors was studied on gelatin phantom as an important element of von Ardenne's Cancer Multistep Therapy. It was found that sufficient and rather homogeneous thermal energy for deep-seated tumors could be provided by the use of divergent rotary magnetic field (wavelength 11.06-22.12 m, 5 kW) with a relative raster motion of the applicators parallel to the body surface by means of a dual system array (CMT Selectotherm System). Therapeutically efficient selective hyperthermia of deep-seated tumors can be achieved without critical superheating of tissues near the skin.

- 5532 ELECTRICAL STIMULATION WITH PT ELECTRODES: I-A METHOD FOR DETERMINATION OF "REAL" ELECTRODE AREAS. (Eng.) Brummer, S. B. (EIC Corp., Newton, MA 02158); Turner, M. J. *IEEE Trans Biomed Eng* 24(5): 436-439; 1977. (9 refs)

An electrical method for determining exposed areas of platinum stimulation electrodes prior to implantation for neurophysiologic studies is described. The method involves using the hydride formation charge as an index of the real area of the electrode, which is exposed to simulated cerebrospinal fluid (CSF) solution after hydrogen evolution is reached. The best solution is buffered saline containing glucose (0.45 g/l) and egg albumin (0.20 g/l). No difference was noted between the use of inorganic-simulated CSF and organic-simulated CSF. There was also no significant difference between the use of increasing pulse widths and decreasing pulses. Nor was any difference found after leaving the electrode without pulsing in the organic-simulated CSF for 3 days. These data show that with pulses employed to reach hydrogen evolution, there is no significant effect of blockage of the surface of the electrode by organic material in the CSF, that is, pulsing effectively keeps the electrode clean. This is significant because no special precautions are needed to attain the ultra-high purity conditions normally needed for accurate electrochemical measurements and because the method appears suitable for subsequent adaptation for use *in vivo*.

- 5533 ELECTRICAL STIMULATION WITH PT ELECTRODES: II-ESTIMATION OF MAXIMUM SURFACE REDOX (THEORETICAL NON-GASSING) LIMITS. (Eng.) Brummer, S. B. (EIC Corp., Newton, MA 02158); Turner, M. J. *IEEE Trans Biomed Eng* 24(5): 440-443; 1977. (6 refs)

The maximum biphasically applied charge, which can be injected without electrolyzing water, was determined for platinum electrodes in simulated cerebrospinal fluid at 37°C. The method involved the use of electrical transients. With lead (anodic first) electrodes, the theoretic non-gassing limit was 300 ± 20 μcoulombs/real cm², independent of current density in the range of ± 50 to ± 450 mA/cm². For lead (cathodic first) electrodes, the theoretic non-gassing limit was 350 ± 50 μcoulombs/real cm² over the same current density range. In both cases only part of the additional charge beyond these limits resulted in water electrolysis. Microscopic observations of bubble formation indicated that these limits were conservative. These limits are sufficiently large for most purposes and do not restrict the use of platinum electrodes for neurologic stimulation.

- 5534 DOSE RATE AND OXYGEN CONSUMPTION RATE IN MICE CONFINED IN A SMALL HOLDER DURING EXPOSURE TO 2450 MHZ MICROWAVE RADIATION. (Eng.) Ho, H. S. (Food and Drug Admin., Bureau of Radiological Health, 5600 Fishers Lane, Rockville, MD 20857); Edwards, W. P. *Radiat Environ Biophys* 14(3): 251-256; 1977. (5 refs)

Radiation dose rates and oxygen consumption rates were measured in 3-mo-old CFI male mice individually

irradiated with 2,450 MHz continuous wave microwave radiation (1.7 W forward power) for 30 min in either small (3.3 x 10.0 x 2.2 cm) or large (9.5 x 9.5 x 4.0 cm) holders. During irradiation in large holders, the microwave energy absorption decreased from 28 mW/g to 21 mW/g accompanied by a decrease in specific metabolic rate from 18 to 14 mW/g. When animals were irradiated in small holders, the average radiation dose rate remained relatively constant at 31.0 mW/g. The specific metabolic rate, however, decreased from 18.7 to 16.3 mW/g during irradiation compared with a mean value of 24.1 mW/g during a 30-min pre-irradiation period. A comparison of the oxygen consumption rates of animals in small and large holders revealed a continually higher oxygen consumption rate for animals in the small holders. A reduction in oxygen consumption rate of animals in the small holders during irradiation indicated that the animals were compensating for the increased heat load by reducing their own heat production. However, this reduction in oxygen consumption was not more than that of animals irradiated in large holders. Hence, the lack of ability of tightly-constrained mice irradiated in small holders to reduce microwave absorption was not compensated for by an additional reduction in oxygen consumption rate.

5535 AN EXAMINATION OF ELECTRIC FIELDS UNDER EHV OVERHEAD POWER TRANSMISSION LINES. (Eng.) Tell, R. A.; Nelson, J. C.; Lambdin, D. L.; Athey, T. W.; Hankin, N. N.; Janes, D. E. (Environmental Protection Agency, Office Radiation Programs, Electromagnetic Radiation Analysis Branch, 9100 Brookville Road, Silver Spring, MD 20910). 46 pp.; 1977. [Environmental Protection Agency Report EPA-520/2-76-008]. (5 refs)

Measured data on electric fields under extremely high voltage (EHV) overhead power transmission lines are presented. The measured maximum electric field strengths beneath 765-kV and 510-kV single circuit lines were approximately 10 kV/m and 5 kV/m at about 3 feet above ground; these field strengths occurred just outside the outer phase conductors. The maximum measured electric field strength beneath a 345-kV double circuit line was about 4 kV/m at the center of the right-of-way and decreased to 1 kV/m and 100 V/m at distances of 69 and 160 feet, respectively, from the center of the right-of-way. Short circuit currents of 2 mA were measured from an EPA radiation analysis van and 0.6 mA from an intermediate sized automobile when they were located in a position where the unperturbed field was about 9 kV/m. An average value of induced body current of about 18 μ A/kV/m was determined for several individuals located in the electric field beneath a 765-kV line. For humans insulated from ground, the threshold for annoyance from transient spark discharge was about 6 kV/m. This is the maximum field strength at 3 feet above ground under the outer phase conductors of a 765-kV line with 60 feet of clearance. It is concluded that under normal conditions electric field strengths under EHV overhead power transmission lines can be calculated with sufficient accuracy to preclude the necessity of field measure-

ments. In addition, it appears that annoyance due to spark discharge is not likely to occur at distances greater than 100 feet from the center of the power line right-of-way, and then only for power lines that are 500 kV or greater.

5536 THE RESPONSE OF SEA URCHIN EGGS AND EMBRYOS TO NON-UNIFORM AC FIELDS. (Eng.) Cohen, R. A. (Ph.D. dissertation, Northeastern University, 1977); 89 pp. [available from Xerox Univ. Microfilms, Ann Arbor, MI 48106, Order No. 77-24,425]. (57 refs)

The response of sea urchin eggs and embryos (*Strongylocentrotus purpuratus*, *Lytechinus pictus*, *Arbacia punctulata*, *Strongylocentrotus droebachiensis*) to non-uniform alternating current fields ranging in frequency from 30 Hz to 100 kHz was investigated to determine if changes in dielectric properties can be detected in a dynamic developmental system. Eggs and embryos in these fields exhibited motion and orientation, and the translational motion was dielectrophoretic in nature. Since dielectrophoresis involves the dielectric properties of matter, stage-specific differences in this behavior imply changes in the embryo's dielectric properties as development proceeds. The collection of unfertilized eggs at the electrode depended on the frequency and voltage of the applied field and on the conductivity and temperature of the dielectrophoretic medium. In some species, unfertilized eggs showed no movement whatever. Changes in jelly coat conductivity probably were responsible for differences observed in unfertilized eggs' behavior at various times after spawning. The collection of developing embryos at the electrodes fell into three distinct intervals of positive response to the field. The first response interval occurred during the first 10 min, probably as a result of the surface events associated with fertilization. The second response interval occurred from 10-40 min after insemination. Between response intervals, there were short periods during which dielectrophoretic movement could not be induced. The third response interval showed variation in dielectrophoretic collection that correlated with the phases of the cleavage cycle. These changes in dielectrophoretic behavior may be a function of the rate of change of embryonic surface charge.

5537 A REVIEW OF CURRENT AND PROPOSED STANDARDS FOR OCCUPATIONAL EXPOSURES TO RADIO-FREQUENCY ENERGY. (Eng.) Odland, L. T. In: *Proceedings of the Annual Conference of NASA Clinic Directors, Environmental Health Officials, and Medical Program Advisors*. Sponsored by the National Aeronautics and Space Administration, pp. 267-278, 1977. (0 refs)

The following essential aspects of an acceptable radiofrequency (RF) occupational exposure control program are reviewed: the setting of exposure limits or guides, the surveillance of the work environment, the medical surveillance of workers, the investigation of actual or suspected accidental overexposures, and the documentation and proper

maintenance of records of all pertinent data applicable to a real or suspected overexposure. A review of exposure standards adopted or being considered by six groups in the United States reveals that for continuous exposures 10 mW/cm^2 has become a consensus, while there is virtually no consensus for permissible brief exposures. With regard to work environment surveillance, only the United States Air Force has a definite goal-oriented program, which involves the inventory, classification, and on-site survey of RF emitters. Only the Department of Defense addresses the question of medical surveillance among various agencies concerned with RF exposures; emphasis is placed on eye examinations. However, an American National Standards Institute proposal represents a first attempt to evaluate changes other than those involving the lens of the eye. Regarding the investigation of accidental overexposures, the Air Force requires investigations whenever there is a suspected overexposure; if subsequent investigation indicates an actual exposure of over 20 mW/cm^2 , the patient is referred for a complete medical evaluation and followup. The Navy requires reports of exposures in excess of 50 mW/cm^2 for any time period and followup medical evaluations at 2- and 4-wk intervals. Provisions for reporting and maintaining records of RF exposure investigations are made by both the Air Force and the Navy.

5538 ON MUTAGENESIS WITH MICROWAVE RADIATION
(MEETING ABSTRACT). (Eng.) Leach, W. M.
(BRH, HEW, 5600 Fishers Lane, Rockville, MD 20857);
Gillespie, L. J. *Health Phys.* 33(6): 661-662; 1978.
(0 refs)

The possibility of microwave-induced mutagenesis is discussed. Although photon energies in the microwave range are not sufficiently large to break chemical bonds in DNA, three lines of indirect and incomplete evidence suggest that microwave radiation may be mutagenic. First, absorption of microwave energy can result in a temperature rise in tissue. Temperature elevation has been shown to cause mutations in *Drosophila*. Second, microwave radiation at 2,450 MHz has been reported to induce chromosomal aberrations. The occurrence of aberrations in irradiated tissue culture cells and in irradiated Chinese hamsters suggests a relationship between chromosomal stickiness and aberrations in studies that utilized acute thermally stressful levels of radiation. Chromosomal aberrations have also been observed in tissue culture cells after long-term irradiation at microwave powers not associated with thermal stress. Third, types of chromosomal changes have been observed that are not amenable to standard cytogenetic analysis. Cells with chromosomal stickiness, which are induced with high microwave powers, and polyploid cells, which appear after both acute and long-term irradiation at 2,450 MHz show irregularities that are similar to the staining of heterochromatic regions associated with differential gene activity. Although mutagenesis with microwave radiation has not been shown, several areas of research are promising. After single acute exposures, tests for chromosomal nondisjunction may be appropriate. For repetitive or chronic exposures, tests for

both nondisjunction and errors of DNA replication may be indicated, and gene expression should be examined.

5539 ASSESSMENT OF THE HYGIENIC SIGNIFICANCE
OF ELECTRIC FIELDS GENERATED BY POWER
TRANSMISSION LINES IN INHABITED AREAS. (Rus.)
Koziarin, I. P. (Dept. General Hygiene, Kiev
Medical Inst., Kiev, USSR); Popovich, V. M. *Vrach
Dela* (11): 120-124; 1977. (7 refs)

The effects of exposure to electrical fields (50 Hz, 120 days) similar to those found along power transmission lines were studied in male rats. Of all the animals, 200 were exposed to 1-15 kV/m-fields 2 hr daily, and 100 animals were exposed to 7, 12, and 15 kV/m-fields 30 min daily. With exposure for 2 hr daily, significant changes were found only in the groups exposed to 7 and 15 kV/m. Compared with the nonexposed controls, significant changes were seen including increases in the latent period of unconditioned reflexes, blood cholinesterase, lactate and succinate dehydrogenase activities, residual nitrogen, urea and glucose levels of the blood, lysozyme level, and reductions were seen in the chronaxy ratio of antagonistic muscles and of the iodine storage capacity of the thyroid gland, and in weight. Change in the color of the fur and loss of hair were also observed at the end of the experiment. The field intensity of 4 kV/m was established as a subthreshold level. In the groups exposed for 30 min daily, significant changes were found in the above characteristics during exposure to 12 and 15 kV/m. The findings indicate that the biologic effects of electrical fields of 50 Hz frequency are a direct function of the length of exposure and the field intensity.

5540 ENVIRONMENTAL BIOPHYSICS BRANCH: SUMMARY
STATEMENT. (Eng.) Chignell, C. F. (No
affiliation given). *Environ Health Perspect* 20:
202-203; 1977. (0 refs)

Research being conducted by the Environmental Biophysics Branch on the effects of nonionizing radiation is summarized. The research includes the development of new microwave exposure systems as well as instrumental and analytical dosimetric techniques. In the health effects area, studies are being conducted on the biophysical mechanisms of the interaction of continuous, pulsed, and modulated 1-10 GHz microwave radiation with biological samples at the cellular and molecular levels. The effects of continuous wave and pulsed 2.45-GHz radiation on the embryonic development and reproductive functions of animals are also being studied. Also being examined are the effects of continuous wave and pulsed 2.45-GHz radiation on the development of the immunologic response in animals and the effect of continuous, pulsed, and modulated 1-10-GHz waves on the central nervous system and on animal behavior. Studies on the biological effects of 2.45-GHz radiation on various in vitro systems have failed to reveal any significant changes other than those directly attributable to thermal heating.

CURRENT LITERATURE

Biological Effects of Nonionizing Electromagnetic Radiation II(4), June, 1978

However, a small decrease in fertility has been observed when male quails exposed in ovo to microwaves were mated with either control or exposed females. Other research involves an examination of the effects of microwaves, electrical fields, and magnetic fields on the biologic rhythms of rats as well as on conditioned behavior of primates and on urinary excretion of various metabolites and other indicators of neurohormone secretion. The effects of chronic exposures to low levels of microwaves are also being investigated, since data on long-term effects are needed for the formulation of microwave radiation safety levels.

5541 **BIOLOGICAL EFFECTS OF STATIC AND LOW-FREQUENCY ELECTROMAGNETIC FIELDS: AN OVERVIEW OF UNITED STATES LITERATURE.** (Eng.) Phillips, R. D.; Kaune, W. T. (Battelle Pacific Northwest Laboratories, Richland, WA). 39 pp; 1977. [available through Electric Power Research Inst., 3412 Hillview Ave., EPRI EA-490-SR]. (106 refs)

A review of United States literature on the biological effects of static and low-frequency electromagnetic fields is presented and discussed in relation to 60-Hz power transmission systems, direct current power transmission systems, and extra-low-frequency communication systems. Based on a long history of experience with electric fields by the utility industry, it appears that intermittent and repeated exposures to strong 60-Hz electromagnetic fields from present power transmission systems have no obvious adverse effect on the health of man. However, this belief must be tested by carefully designed and executed experiments under laboratory conditions where precise control can be exercised over coexisting environmental factors. There is only one direct current transmission system currently in operation in the United States, namely, the 400-kV Celilo-Sylmar Intertie between northern Oregon and southern California. Little meaningful biological research has been conducted that simulates exposures to such a system. Factors in addition to the static electric and magnetic fields such as ion currents, air ions, and possibly ozone must be considered. A comprehensive research program to assess the possible bioeffects of exposure to low level, extra-low-frequency radiation from communication systems, such as, the Navy's proposed Project Sanguine, is in progress. The results of this research program are tabulated in terms of effects on physiology, growth and development, behavior, genetics, and biochemistry.

5542 **INFLUENCE OF HIGH MAGNETIC FIELDS ON MEIOSIS.** (Eng.) Linskens, H. F. (Dept. Botany, Section Molecular Developmental Biology, Univ. Nijmegen, Netherlands); Smeets, P. S. *Experientia* 34(1): 42; 1978. (5 refs)

Experiments on the influence of high magnetic fields on meiotic division in plants are reported. Whereas no significant influence of a 10,000-G magnetic field on mitotic frequency in root tips of *Vicia faba*

was observed, increases in the number of chromosomal aberrations were observed in the sporogenous tissue of anthers exposed to a magnetic field. Anthers of lily, after treatment in a homogeneous magnetic field of 5,000 G for 4 hr, showed a significant number of disturbed Anaphases I and Telophases I immediately after the exposure. The deviations were more numerous 18-24 hr after the magnetic treatment, with the number of disturbed Anaphases II and Telophases II being significantly higher than in controls. Synchronism of the meiotic divisions was also reduced so that various stages were observed at the same time in one loculus. However, 48-50 hr after magnetic field exposure, the number of chromosomal aberrations was reduced, with no significant difference between exposed anthers and controls; therefore, a self restitution can be concluded. The aberrations observed were mostly bridges, fragmentations, and isolated chromosomes. It is suggested that the explanation for the biomagnetic effects on meiotic division includes disorder of the nucleic acid and protein synthesis, since it has been shown that nucleic acids are diamagnetic anisotropic substances.

5543 **EFFECTS OF ELECTRIC FIELDS ON LARGE ANIMALS (INTERIM REPORT).** (Eng.) Phillips, R. D.; Gillis, M. F.; Richardson, R. L.; Allen, C. H.; Kaune, W. T.; Beamer, J. L.; Jeffs, T. W.; Decker, J. R. (Battelle Pacific Northwest Lab., Richland, WA). 65 pp., 1977. [available through Electric Power Research Inst., 3412 Hillview Ave., Palo Alto, CA 94304, Document No. EPRI EA-458]. (4 refs)

The planning and construction of housing and experimental facilities for the chronic exposure of the Hanford Miniature Swine to uniform, single-phase, vertical 60-Hz electric fields of at least 30 kV/m in intensity are reported. The goal of the project is to ensure constant well-defined exposure of large test subjects to electric fields, while holding all other parameters constant for test and control animals. The electrode system, with vibration damping, is complete. Using a test-transformer, the field over the area to be occupied by swine is vertical to within 2 degrees and constant in magnitude to within 6%. Breeding of the F₀ generation of swine is nearing completion, and preliminary growth data, and blood chemistry are being collected. The goal is to obtain 40 female piglets of similar size and shape so that dosimetry will be comparable. Using full-scale models of pigs, surface fields and dosimetry are being characterized. This data plus data collected for a related study on small animals will provide a basis for defining the internal dose of radiation received by the swine and for extrapolating results to man.

5544 **GROWTH OF BARLEY IN MAGNETIC FIELD OF VERY LOW INTENSITY.** (Rus.) Lebedev, S. I. (Kiev, USSR); Baranskii, P. I.; Litvinenko, L. G.; Shlian, L. T. *Elektronnaya Obrabotka Materialov* (3): 71-73; 1977. (20 refs)

The effect of permanent magnetic field of very low intensity (8×10^{-3} Amp-turn/m) on the growth of

barley plants was studied. The plants were exposed for 3 wk after sowing. Control plants were exposed to normal geomagnetic field (~ 32 Amp-turns/m) under otherwise identical conditions. The wet weight of the aerial mass of one plant was 414-433 mg vs. 465-555 mg in the control ($p<0.05$). The dry weight of the aerial part of one plant was 29.8-36.7 mg vs. 35.7-46.4 mg in the control. The wet weight of the root of one plant averaged 36.9-67 mg vs. 49.9-93 mg in the control ($p<0.05$), and the respective dry weights were 4.8-5.78 mg and 7.2-8.2 mg. The numbers of plants with three leaves were 39.4-50% vs. 58.7-87% in the control. The findings indicate the significant growth-stimulating effect of the geomagnetic field compared with the artificial low-intensity field and suggest the possibility of the considerable consequences of the exposure to zero magnetic field in astronauts.

5545 ENVIRONMENTAL INFLUENCES ON THE IMMUNE SYSTEM AND ALLERGIC REACTIONS. (Eng.)
Adkinson, N. F. (Div. Clinical Immunology, Dept. Medicine, The Johns Hopkins Univ. Sch. Medicine, The Good Samaritan Hosp., Baltimore, MD 21239). *Environ Health Perspect* 20: 97-103; 1977. (18 refs)

Environmental influences of physical agents on the immune system are discussed. Although it has been long recognized that appreciable doses of ionizing radiation may result in immunodeficiency states of various degrees, the effects of nonionizing electromagnetic radiation, including microwave transmission, are less studied. At present there is no reason to suspect that the routine use of roentgenography in medicine or dentistry or radiation exposure from appliances, such as, color television sets and microwave ovens can induce significant states of immunodeficiency. It is suggested that studies of the effect of chronic low-dose exposures to environmental agents on immune responsiveness be pursued in carefully selected areas, such as, studies of physical and chemical agents for which there is some indication of selective toxicity for the immune system.

5546 LABORATORY OF ENVIRONMENTAL BIOPHYSICS: SUMMARY STATEMENT. (Eng.) Fouts, J. R. (No affiliation given). *Environ Health Perspect* 20: 200-201; 1977. (0 refs)

The nonionizing radiation research program of the Laboratory of Environmental Biophysics is outlined. The objectives of the program are as follows: to develop microwave exposure systems for bioeffects research; to develop and test techniques for measuring microwave energy absorption; to determine the effect of microwaves on isolated nerve preparations; to determine how 2,450 MHz microwave radiation interacts with biological systems at all levels; to study the effect of long-term exposures of experimental animals to 915 MHz and 2,450 MHz radiation in terms of the central nervous system and behavior; and to ascertain the effect of 60-Hz fields from high voltage transmission lines on the central nervous systems of mammals. A waveguide

system for exposing isolated nerves to microwave radiation has been fabricated and tested, and a 2,450-MHz absorber-lined horn system has been modified to permit the exposure of pregnant mice. Equipment has also been built to measure the colonic temperature of mice during microwave exposure. Studies on the biological effects of 2,450-MHz radiation on various in vitro systems have failed to reveal any significant changes other than those which are directly attributable to heating. However, a small decrease in fertility was observed when male quail that had been exposed in ovo to microwaves were mated with either control or exposed females. Preliminary results from studies on the long-term effects of 915-MHz radiation on rats suggest that the exposure of pregnant rats to such radiation does not alter the relative numbers of viable offspring and stillborns. Studies on the long-term effects of microwave exposure on the central nervous system and behavior of rats are still ongoing. The effect of the long-term exposure of rats to 60-Hz fields is also being studied.

5547 BACKGROUND INFORMATION ON HIGH VOLTAGE FIELDS. (Eng.) Janes, D. E. (United States Environmental Protection Agency, Office Radiation Programs, 9100 Brookville Road, Silver Spring, MD 20910). *Environ Health Perspect* 20: 141-147; 1977. (24 refs)

A review of the biological effects of high voltage fields is discussed in relation to the increasing use of higher voltages for overhead power transmission lines. Only a small amount of work had been done to explore the possible effects, especially long term effects, of transmission line electric fields on biological systems. Research in the United States and Western Europe has not identified any acute or prompt effects from such exposures other than spark and electric discharge effects; no permanent effects have been observed. Effects such as excitability, headaches, drowsiness, fatigue, and nausea have been reported for workers in Soviet and Spanish high voltage switchyards. However, these effects have not been seen in workers who perform maintenance on Soviet extra-high-voltage transmission lines and therefore may be due to a unique switchyard environment rather than exposure to intense electric fields. The results of current and planned research, supported by both the United States Government and by the private sector, should resolve a number of the present uncertainties concerning the potential effects of high voltage fields.

5548 BIOMAGNETIC EFFECTS: A CONSIDERATION IN FUSION REACTOR DEVELOPMENT. (Eng.) Mahlum, D. D. (Battelle, Pacific Northwest Lab., Richland, WA 99352). *Environ Health Perspect* 20: 131-140; 1977. (65 refs)

A literature review of the biological effects of magnetic fields is discussed in relation to the hazard potential of occupational exposures to substantial magnetic fields in nuclear fusion power

plants. Magnetic fields of up to 450 G may be encountered in some working areas. The available data indicate that magnetic fields can interact with biological material to produce effects, although the reported effects are usually small in magnitude and often unconfirmed. Changes in the electrical activity of the brain and heart have been observed after the exposure of humans, monkeys, rabbits, and pigeons to fields of 500-91,000 G. Other effects observed in humans exposed to magnetic fields include the visualization of light flashes and transient rises in serum triglyceride levels. The existing data base is concluded to be totally inadequate for the assessment of the potential health and environmental consequences of magnetic fields and for the establishment of appropriate standards. Requisite studies to provide an adequate data base are outlined.

5549 ENHANCED CYTOTOXIC EFFECT OF HYPERTERMIA (43 C) FOR COLCEMIDE-TREATED NORMAL AND SV₄₀-TRANSFORMED CELLS GROWN IN VITRO. (Eng.) Szmigelski, S. (11/3 Pulawska, 02-515 Warszawa, Poland). Kobus, M.; Janiak, M. *Arch Gesamtforsh* 47(5): 396-399; 1977. (13 refs)

The effect of microwave- and water bath-produced hyperthermia on colcemide-treated normal and transformed mouse fibroblasts grown in vitro was investigated in relation to the potential use of hyperthermia in cancer therapy. Normal mouse fibroblasts (L-929 cells) and transformed (SV₄₀) mouse fibroblasts grown in vitro were treated for 4 hr with 5 μ g/ml of colcemide and heated for 2 hr by means of a 43 C water bath or by 3-GHz-microwaves. Normal cultures and colcemide-treated cultures grown at 37 C served as controls. Hyperthermia induced by water bath heating or by irradiation lowered the viability of normal and transformed fibroblasts and inhibited the incorporation of thymidine, uridine, and glycine into the cells. Transformed fibroblasts pretreated with colcemide were more sensitive to hyperthermia than colcemide-treated normal fibroblasts. The difference in the reaction of normal and transformed fibroblasts to hyperthermia was more pronounced in microwave-heated cells than in cultures heated in a water bath. It is suggested that the stronger inhibition of cell metabolism in cultures heated with microwaves may be due to the specific molecular effect of microwaves in biological materials and that colcemide treatment enhances the thermosensitivity of transformed cells to a higher degree than normal cells. This observation may be of interest when planning a potent scheme for the selective injury of cancer cells by hyperthermia combined with drugs that influence the cell cycle.

5550 DNA SYNTHESIS IN CARTILAGE CELLS IS STIMULATED BY OSCILLATING ELECTRIC FIELDS. (Eng.) Rodan, G. A. (Dept. Oral Biology and Orthodontics, Univ. Connecticut, Sch. Medicine and Dental Medicine, Farmington, CT 06032); Bourret, L. A.; Norton, L. A. *Science* 199(4329): 690-692; 1978. (28 refs)

The effect of an oscillating electric field on deoxyribonucleic acid (DNA) synthesis in cartilage cells was investigated to contribute to the understanding of epigenetic control of growth and differentiation. A pulsed direct current external electric field of 1,166 V/cm oscillating at 5 Hz stimulated the incorporation of radiolabeled thymidine into the DNA of chondrocytes isolated from the proliferative layer of embryonic (16 days) chick epiphysis by 53 \pm 13%. The effect appeared to be tissue specific, since it was not observed in some other tissues, such as, skin fibroblasts obtained by collagenase digestion from 10-day-old chick embryos. Tetracaine hydrochloride at a concentration of 10^{-6} molar partially inhibited the incorporation of thymidine in both control and electrically stimulated cells, and Verapamil or tetrodotoxin at concentrations of 10^{-6} molar completely blocked the electric field effect. The above findings support the hypothesis that sodium and calcium ion fluxes generated by the electrical perturbation trigger DNA synthesis in these cells.

5551 MICROWAVE HEARING IN MAMMALS AT 3.0 GHZ. (Eng.) Cain, C. A.; Rissman, W. J. In: *Biological Effects of Electromagnetic Waves: Selected Papers of the USNC/URSI Annual Meeting*, Boulder CO, October 20-23, 1975. Sponsored by U.S. National Committee of the International Union of Radio Sciences, National Academy of Sciences (Washington, DC): Vol. 1, pp. 79-88, 1976. (15 refs)

The effects of 3.0-GHz microwave pulses on the auditory systems of cats, dogs, chinchillas, and humans were investigated to determine microwave hearing threshold parameters for different mammalian species. The average energy density per microwave pulse at the threshold of producing an auditory-evoked response in the animals studied was $10.3 \mu\text{J}/\text{cm}^2$ at pulse widths of less than 20 μsec . The average threshold energy density of microwave pulses that could be heard by human subjects was $10.6 \mu\text{J}/\text{cm}^2$ for pulse widths of less than 20 μsec . However, three of eight subjects could not hear pulses below 20 μsec in width at maximum peak power settings. There was no clear correlation between ability to hear microwave pulses and hearing threshold as measured by standard audiograms. However, these audiograms did not test hearing thresholds above a frequency of 8 kHz, and it is possible that an inability to hear microwave pulses can be correlated with hearing losses at higher frequencies.

5552 RELATIVE CATARACTOGENIC POTENCIES OF TWO MICROWAVE FREQUENCIES (2.45 and 10 GHz). (Eng.) Hagan, G. J.; Carpenter, R. L. In: *Biological Effects of Electromagnetic Waves: Selected Papers of the USNC/URSI Annual Meeting*, Boulder CO, October 20-23, 1975. Sponsored by U.S. National Committee of the International Union of Radio Sciences, National Academy of Sciences (Washington, DC): Vol. 1, pp. 143-155, 1976. (26 refs)

The role of microwave frequency in the experimental induction of lens opacities was investigated by

irradiating the eyes of rabbits for 30 min with either 2.45- or 10-GHz continuous wave radiation at various power levels. A dielectric lens was used to focus radiation on the eye region, with distances from the emitting horn to the dielectric lens and from the latter to the eye kept the same in all experiments. The induction of lens opacities required less power at the lower frequency. At 2.45 GHz, the lowest power density at which opacities developed in more than 50% of the experiments was 295 mW/cm²; whereas, at 10 GHz, the lowest power density for a corresponding effect was 375 mW/cm². At 2.45 GHz, all eyes exposed to power densities of 325 mW/cm² or greater developed opacities; whereas, at 10 GHz, this occurred only when the power density was higher than 410 mW/cm². At a frequency of 10 GHz, more heating occurred in the aqueous humor of the anterior chamber in front of the lens, while heating was greater in the vitreous body behind the lens at the lower frequency. The focusing factor of the dielectric lens used was greater for the higher frequency. The lower frequency clearly possessed greater cataractogenic potency despite the fact that the 10 GHz frequency had a considerably greater heating effect on the aqueous humor.

5553 SANGUINE EXTREME LOW FREQUENCY ELECTROMAGNETIC FIELDS: EFFECT OF LONG-TERM EXPOSURE ON SOIL ARTHROPODS AND OTHER ANIMALS IN NATURE. (Eng.) Greenberg, B. In: *Biological Effects of Electromagnetic Waves: Selected Papers of the USNC/URSI Annual Meeting, Boulder CO, October 20-23, 1975*. Sponsored by U.S. National Committee of the International Union of Radio Sciences, National Academy of Sciences (Washington, DC): Vol. 1, pp. 187-200, 1976. (12 refs)

Demographic analyses of soil arthropods and metabolic studies of five animal species are being conducted at the Wisconsin test facility containing the Navy's Project Sanguine extreme low frequency low energy communications system to determine the long-term biologic impact of this system. Since 1972, there has been considerable overlap in predator-prey proportions in paired test and control plots, suggesting similar population structure and function. These proportions have shown less annual variation in exposed plots than in control plots. After 6 yr of exposure to extreme low frequency radiation, the ratio of *Cryptostigmata* to *Collembola* in the original Hazleton test plot is almost exactly the same as in 1969, before antenna turn-on. A total of 23 tests measuring oxygen consumption and respiratory quotient in earthworms, redworms, slugs, woodlice, and redbacked salamanders has revealed two marginally significant differences in the metabolic rates of exposed animals. In 1972, exposed woodlice had a higher metabolic rate, but six tests performed in subsequent years have disclosed no significant differences. The metabolic rate of exposed redworms was lower in 1974, but not before or after. Field and laboratory observations of the above animals have produced no evidence of abnormalities in behavior, habitat selection, or external features and pigmentation.

5554 EFFECTS OF A FIELD FREE SPACE ON THE CIRCADIAN ACTIVITY RHYTHM OF THE HOUSE SPARROW, *PASSER DOMESTICUS*. (Eng.) Bliss, V. L.; Heppner, F. H. In: *Biological Effects of Electromagnetic Waves: Selected Papers of the USNC/URSI Annual Meeting, Boulder CO, October 20-23, 1975*. Sponsored by U.S. National Committee of the International Union of Radio Sciences, National Academy of Sciences (Washington, DC): Vol. 1, pp. 225-237, 1976. (24 refs)

Experiments were performed to test the hypothesis that cyclic changes in the intensity of the earth's magnetic field can entrain the circadian activity rhythm of the house sparrow, *Passer domesticus*. Two sets of Weber coils were constructed: one set for experimental birds and one for controls. The set of experimental coils was regulated by a power supply that compensated the intensity of the earth's magnetic field within the coil to 0 G ± 200 gammas. Eight nonmagnetic cages (one bird per cage) were placed within each coil. The perch-hopping activity of each bird was monitored by an event recorder. Both experimental and control birds were entrained to a light-dark 8-hr:16-hr cycle for 2 wk. For 2 more wk, the light cycle was maintained, while the experimental birds were exposed to a near 0 G field for 8 hr a day; these 8 hr of near 0 G field were synchronized with the light period. For the last 4 wk of the experiment, all birds were placed in constant darkness, with the magnetic field cycle being maintained for the experimental birds. Enright's periodogram analysis, analysis of covariance, and circular statistics showed a significant difference between the two groups of birds. The periodogram showed that the period lengths of the control birds were longer than those of the experimental birds. Analysis of covariance showed that control birds were significantly more active between 1800 and 2400 hr of the day compared with experimental birds. Circular statistics indicated that the midpoints of activity time were significantly later for controls than for experimental birds.

5555 THE INSOUCIANT SPARROWS OF CONSTANTINOV: A CASE STUDY OF ELECTROMAGNETIC ETHOLOGY. (Eng.) Bem, D. J.; Trzaska, H. In: *Biological Effects of Electromagnetic Waves: Selected Papers of the USNC/URSI Annual Meeting, Boulder CO, October 20-23, 1975*. Sponsored by U.S. National Committee of the International Union of Radio Sciences, National Academy of Sciences (Washington, DC): Vol. 1, pp. 284-288, 1976. (5 refs)

Observations on sparrows nesting within a pseudo-coaxial line of an antenna used for transmitting longwave (277 kHz) radio signals are reported. The antenna, located in Constantinov, Poland, was a vertical anti-fade type with a height of 646 m and a capability of radiating radio frequency energy in excess of 2 MW. The sparrows built a nest within the inner array of wires of the pseudo-coaxial line near the feed point of the antenna. The avian parents made frequent trips from nest to beyond, from inner through outer conductors of the pseudo-

coaxial line, and from microvolt to kilovolt fields. Once hatched, the baby sparrows stretched their necks until their heads were in the energy rich region between inner and outer conductors of the pseudo-coaxial line. Gross but virtually constant observation of the birds by radio station operating personnel over a period of weeks revealed no ill effects or deviant behavioral changes in the avian parents or in their brood.

5556 INTERACTIONS BETWEEN NERVOUS TISSUES AND WEAK ENVIRONMENTAL ELECTRIC FIELDS. (Eng.) Bawin, S. M.; Adey, W. R. In: *Biological Effects of Electromagnetic Waves: Selected Papers of the USNC/URSI Annual Meeting, Boulder CO, October 20-23, 1975*. Sponsored by U.S. National Committee of the International Union of Radio Sciences, National Academy of Sciences (Washington, DC): Vol. 1, pp. 323-330, 1976. (26 refs)

Isolated chick cerebral hemispheres and striated muscle specimens as well as cat cerebral cortex were preincubated with radioactive calcium and exposed to extremely-low-frequency fields (1-75 Hz). These experiments were performed to determine if previously observed increases in calcium efflux from chick brain tissues exposed to amplitude-modulated very-high-frequency fields were the result of the 147 MHz carrier wave in conjunction with the modulation or were due solely to the low-frequency amplitude modulation component of the radiation. Decreases in calcium efflux from chick brain tissue were seen under most field conditions when brain samples were separately exposed to fields at 1, 6, 16, and 32 Hz at peak field gradients of 5, 10, 56, and 100 V/m. Maximal and statistically significant decreases in calcium efflux occurred with field gradients of 10 V/m at 6 and 16 Hz and 56 V/m at the same frequencies. Chick muscle tissues were unaffected by a field condition (16 Hz, 10 V/m) that induced a decrease in calcium release from brain tissues. In cat cerebral cortex, significant reductions in calcium release occurred at 6 Hz and 16 Hz at 56 V/m field gradients. These studies indicate that inhibition of calcium release in isolated chick and cat cerebral tissue exposed to extremely-low-frequency fields depends on both the frequency and amplitude of the incident field. Since previous experiments with amplitude-modulated very-high-frequency fields showed an equal but opposite effect (increased calcium exchange) when the carrier wave was amplitude modulated over a narrow band of frequencies (6-20 Hz), the effects observed in these previous experiments appear to be the results of both the high frequency carrier signal and the low frequency modulation component. Since striated muscle appeared to be insensitive to fields that elicited a clear response in brain tissue, nervous tissue appears to have unique physical properties that render it sensitive to specific extremely weak electrical stimulation.

5557 THE SLEEP PROCESS OF RABBITS EXPOSED TO LOW INTENSITY NON-IONIZING ELECTROMAGNETIC RADIATION. I. DEVELOPMENT OF METHODOLOGY. (Eng.)

Manthel, R. C.; Glaser, Z. R. In: *Biological Effects of Electromagnetic Waves: Selected Papers of the USNC/URSI Annual Meeting, Boulder CO, October 20-23, 1975*. Sponsored by U.S. National Committee of the International Union of Radio Sciences, National Academy of Sciences (Washington, DC): Vol. 1, pp. 341-351, 1976. (11 refs)

Chronic recordings of electrocorticograms, electro-oculograms, and electromyograms were obtained daily from adult male rabbits on a 24-hr basis following daily 2-hr pulsed microwave exposure at 3.7 GHz (1,000 pulses/sec, 60% duty cycle, 10 mW/cm² power density) for 60 days to develop a methodology for determining the effects of nonionizing electromagnetic radiation on the sleep process of animals. A surgical implant assembly was designed to allow for chronic postirradiation recording, while allowing no metallic elements to be associated with the subjects during microwave exposure. A unique application of logic circuitry allowed for the quantification of both the frequency and duration of rapid eye movement sleep stage episodes. Although it is too early to comment on the possible relationships between electromagnetic radiation and paradoxical sleep, the sleep process is viewed as a potential index of central nervous system adaptation to prolonged electromagnetic radiation exposure.

5558 A COAXIAL AIR LINE MICROWAVE EXPOSURE SYSTEM: RESPIRATORY ACTIVITY OF MITOCHONDRIA IRRADIATED AT 2-4 GHZ. (Eng.) Elder, J. A.; Ali, J. S.; Long, M. D.; Anderson, G. E. In: *Biological Effects of Electromagnetic Waves: Selected Papers of the USNC/URSI Annual Meeting, Boulder CO, October 20-23, 1975*. Sponsored by U.S. National Committee of the International Union of Radio Sciences, National Academy of Sciences (Washington, DC): Vol. 1, pp. 352-365, 1976. (20 refs)

A system was developed to continuously circulate rat liver mitochondria through a coaxial air line and oxygen electrode cell so that mitochondria were exposed to 2-4 GHz microwave radiation while biochemically active and so that respiration could be measured as the mitochondrial suspension flowed from the air line. The rat liver mitochondria were irradiated for approximately 10 min at frequencies of 2.45, 3.0, and 3.4 GHz at 41 W/kg or at a low absorbed dose rate of 1.6-2.3 W/kg over a frequency range of 2-4 GHz at sweep times of 0.1 and 30 sec. Rates of respiration, respiratory control ratios, and adenosine diphosphate/oxygen ratios were determined at 30°C with succinate, pyruvate, and β -hydroxybutyrate as substrates. No difference in the respiration and oxidative phosphorylation of control and irradiated mitochondria was observed.

5559 THE EFFECTS OF 19 NEGACYCLE IRRADIATION ON MICE AND RATS. (Eng.) Stavrinou, W. B.; Medina, M. A.; Frazer, J.; Weintraub, S. T.; Ross, D. H.; Modak, A. T.; Jones, D. J. In: *Biological Effects of Electromagnetic Waves: Selected Papers*

of the USNC/URSI Annual Meeting, Boulder CO, October 23-23, 1975. Sponsored by U.S. National Committee of the International Union of Radio Sciences, National Academy of Sciences (Washington, DC): Vol. 1, pp. 431-448, 1976. (25 refs)

Mice and rats exposed to 19-MHz radiation with a magnetic field of 55 A/m and an electric field of 8,000 V/m in a near field synthesizer were compared with similar animals exposed in a thermal environment that produced a comparable rise in body temperature to measure physiologic systems known to be affected by hyperthermia. The growth of mice exposed to radiation on days 5 through 10 after birth was not affected. After the exposure of adult mice for 40 min/day for 5 days, a substantially higher death rate was observed in both irradiated and thermally heated male mice compared with similarly treated female mice and male control mice. The irradiation and thermal treatments produced an average rise in rectal temperature of approximately 1 C. After irradiation, 28% of the male mice died, while only 5% of the female mice died. Thermal exposure produced a death rate of 21% in male mice and 38% in female mice. After single 40-min radiation or thermal exposures of rats, the average rise in rectal temperature was approximately 1 C. No lethality was observed in either irradiated or thermally heated rats, and no remarkable changes were seen in the levels of acetylcholine or catecholamines after irradiation or thermal exposure. Although no changes were seen in cyclic adenosine monophosphate after irradiation, some irradiation-related changes in high energy phosphates were seen. Significant changes were seen in the concentrations of several cations in the brain after irradiation; most notably, the zinc concentration in the cerebral cortex increased from 0.28 μ mole/mg to 0.53 μ mole/mg after irradiation. By far the most striking effect of the radiation exposure of rodents in these experiments was the increased death rate of male mice.

5560 QUANTIFICATION AND MEASUREMENT OF INDUCED FIELDS INSIDE FINITE BIOLOGICAL BODIES.
(Eng.) Chen, K.-M.; Guru, B. S.; Nyquist, D. P. In: *Biological Effects of Electromagnetic Waves: Selected Papers of the USNC/URSI Annual Meeting, Boulder CO, October 20-23, 1975*. Sponsored by U.S. National Committee of the International Union of Radio Sciences, National Academy of Sciences (Washington, DC): Vol. II, pp. 19-43, 1976. (13 refs)

Electric fields induced in finite biologic bodies by incident electromagnetic radiation were theoretically quantified by a tensor integral equation method and experimentally measured by insulated field probes. For the experimental measurements, a number of experimental models with various dimensions were constructed with plexiglas and filled with a saline solution. The models were irradiated at frequencies ranging from 1.7-3.0 GHz (with 1 kHz modulation). Excellent agreement was obtained between theory and experiment. Some minor

discrepancies between theoretic and experimental results on total induced electric field were found to exist near the edges of the body due to an inherent experimental error associated with the implantable field probe. The tensor integral equation was used to quantify the total electric field and the absorbed power density in a human torso induced by vertically and horizontally polarized electromagnetic waves at various frequencies. In the numeric calculation of the tensor integral equation, sufficiently accurate results were obtained if the size of the cells was kept smaller than one-fourth of the free-space wavelength. Although with this cell size it is not possible to predict the exact pattern of the standing wave inside the body, it was accurate enough to predict the induced electric field at the centers of the cells. If a more accurate pattern of the standing wave is needed, it is only necessary to reduce the cell size at the expense of increasing the computing time. The numeric tensor integral equation method can produce exact solutions for the induced electric field in any arbitrarily-shaped biologic body, with the only limitations being computing time and computer storage capacity.

5561 MEASUREMENT OF RADIOFREQUENCY POWER ABSORPTION IN MONKEYS, MONKEY PHANTOMS, AND HUMAN PHANTOMS EXPOSED TO 10-50 MHZ FIELDS. (Eng.) Allen, S. J.; Hurt, W. D.; Krupp, J. H.; Ratliff, J. A.; Durney, C. H.; Johnson, C. C. In: *Biological Effects of Electromagnetic Waves: Selected Papers of the USNC/URSI Annual Meeting, Boulder CO, October 20-23, 1975*. Sponsored by U.S. National Committee of the International Union of Radio Sciences, National Academy of Sciences (Washington, DC): Vol. II, pp. 83-95, 1976. (7 refs)

Perturbation analysis theory was applied to the prolate spheroid model to determine the theoretic power absorption over a broad range of frequencies and to check the validity of these calculations using prolate spheroid phantoms to represent man and monkeys. Power absorption measurements in live monkeys were made to determine the validity of the prolate spheroid model. The perturbation analysis when coupled with an ellipsoid model successfully predicted absorbed power in animals. Prolate spheroid theory and measurement predicted low levels of power absorption for man exposed to 10-30 MHz radiofrequency fields. For 50 mW/cm² exposures with cross polarization, only 12 W of total power absorption was predicted at 30 MHz; at 10 MHz, slightly over 1W total absorbed power was predicted. Compared with man's basal metabolic rate of 80 W at rest to 600 W for heavy labor, 50 mW/cm² at frequencies below 30 MHz represents an almost insignificant thermal insult. Power absorption measurements for monkey phantoms and live monkeys over frequencies of 10-50 MHz revealed that the absorbed power decreases approximately as the square of the frequency decreases for all phantom as well as monkey exposures. These data indicate the need for frequency-dependent radiofrequency radiation hazard standards.

- 5562 THE NUMERICAL THERMAL SIMULATION OF THE HUMAN BODY WHEN ABSORBING NON-IONIZING MICROWAVE IRRADIATION--WITH EMPHASIS ON THE EFFECT OF DIFFERENT SWEAT MODELS. (Eng.) Emery, A. F.; Short, R. E.; Guy, A. W.; Kraning, K. K.; Lin, J. C. In: *Biological Effects of Electromagnetic Waves: Selected Papers of the USNC/URSI Annual Meeting, Boulder CO, October 20-23, 1975*. Sponsored by U.S. National Committee of the International Union of Radio Sciences, National Academy of Sciences (Washington, DC): Vol. II, pp. 96-118, 1976. (61 refs)

The human body was numerically simulated to determine the thermal response of the body to the absorption of nonionizing radiation, with particular emphasis on the effect of different sweat rate models. Three cases were considered: energy deposited in the head according to the solution for a conducting sphere, energy deposited in the body in proportion to the tissue mass, and energy deposited according to phantom model and numeric results for a standing human. Short and long time exposures were modeled by permitting the blood flow to vary according to an effective local metabolic production. Substantial differences were found by using different sweat models, emphasizing the need for further work in defining the precise nature of sweating and its response to external stimuli. Calculations made assuming that the blood flow can adjust to the apparent local metabolic rate suggest that such adjustments will increase the central core temperatures, thus aggravating the problems associated with the absorption of non-ionizing radiation.

- 5563 THE ATTENUATION FUNCTION FOR BIOLOGICAL FLUIDS AT MILLIMETER AND FAR-INFRARED WAVELENGTHS. (Eng.) Illinger, K. H. In: *Biological Effects of Electromagnetic Waves: Selected Papers of the USNC/URSI Annual Meeting, Boulder CO, October 20-23, 1975*. Sponsored by U.S. National Committee of the International Union of Radio Sciences, National Academy of Sciences (Washington, DC): Vol. II, pp. 169-182, 1976. (27 refs)

An attenuation function for biologic fluids at millimeter and far-infrared wavelengths exhibiting relaxation and resonance absorption of electromagnetic radiation is described via a theoretic model, which evades the (physically) incorrect limit for the attenuation function for a Debye-type relaxation process. The collisional interruption of absorption and emission of electromagnetic radiation by molecular fluids is treated in terms of a formulation describing the efficiency of collisional perturbation as a function of the field frequency. The attenuation function, and hence the depth of penetration, is computed on the basis of this model, and the results of the theory are compared with existing experimental results for liquid water and typical biologic tissue. Whereas the Debye assumption precludes the existence of windows in the attenuation function for a polar liquid like water above the microwave region, the present model is consistent with a rapid increase in the relaxation contribution to the attenuation distance for frequencies of about 10^4 GHz. This

prediction has implications not only for the penetration of electromagnetic radiation into aqueous systems and biologic tissues but also for the profile of blackbody radiation emitted by biologic tissues at the millimeter and far-infrared frequencies and hence the radiometry and thermography of tissues in these frequency regions.

- 5564 INTERACTION OF MICROWAVE FREQUENCY AND POLARIZATION WITH ANIMAL SIZE. (Eng.) Schrot, J.; Hawkins, T. C. In: *Biological Effects of Electromagnetic Waves: Selected Papers of the USNC/URSI Annual Meeting, Boulder CO, October 20-23, 1975*. Sponsored by U.S. National Committee of the International Union of Radio Sciences, National Academy of Sciences (Washington, DC): Vol. II, pp. 184-192, 1976. (13 refs)

Latency to tonic-clonic convulsion was measured in mice (25-30 g), small rats (100-125 g), and large rats (380-420 g) as they were individually exposed to a 150-mW/cm² continuous wave microwave field to investigate the interaction of microwave frequency and polarization with animal size. Groups of animals were exposed to different combinations of frequency and polarization. Frequencies of 710, 985, 1,700, 2,450, and 3,000 MHz were used and at each frequency the electric field was polarized either horizontally or vertically and aligned parallel or perpendicularly, respectively, with the long axis of the animal's body. The results showed that interactions do occur between microwave frequency and animal size. Maximum vulnerability occurred at lower frequencies as animal size increased. With a horizontally polarized electric field the animals were most sensitive when body length was about one-half of the wavelength. The horizontally polarized electric field consistently produced the shortest convulsion latencies. Furthermore, as animal size increased, the field parameters interacted to produce larger polarization differentials at lower frequencies. The results support arguments for the careful consideration of both field parameters and target dimensions in hazards evaluation.

- 5565 PERFORMANCE OF THE LCOF PROBE IN CALORIMETRIC AND TISSUE TEMPERATURE MONITORING APPLICATIONS. (Eng.) Livingston, G. K.; Rozzell, T. C.; Johnson, C. C.; Durney, C. H. In: *Biological Effects of Electromagnetic Waves: Selected Papers of the USNC/URSI Annual Meeting, Boulder CO, October 20-23, 1975*. Sponsored by U.S. National Committee of the International Union of Radio Sciences, National Academy of Sciences (Washington, DC): Vol. II, pp. 239-248, 1976. (4 refs)

Performance parameters obtained during a series of calorimetric and hyperthermic experiments are reported for a liquid crystal optic fiber (LCOF) probe designed to obviate perturbation problems induced by metallic sensor components during temperature measurements in microwave heating experiments. The temperature probe has two shortcomings:

hysteresis and ageing of the sensing medium. Experimental results have consistently shown that reflectance for the body temperature probe (32-45°C) heated to 45°C does not remain constant over the course of one day's experiments but drifts gradually downward. If the shift in the probe's response is monitored by periodic calibrations, the accuracy can be held to 0.1°C and often less. Otherwise, the drift problem results in errors of 0.25°C when only one calibration is performed. The ageing effect of the probe's sensing medium results in progressive decay in the response curve over a time period of intensive use. However, in terms of useful life of the sensor, many months of reliable performance have been demonstrated with one such probe being accurate to 0.1°C after 9 mo of use in hyperthermia experiments on several hundred mice. Overall, the shortcomings of the probe can be controlled or minimized so that this thermal sensing device has considerable practical value.

5566 EXPERIMENTAL CALIBRATION OF A MINIATURE ELECTRIC FIELD PROBE WITHIN SIMULATED MUSCULAR TISSUES. (Eng.) Cheung, A.; Bassen, H.; Swicord, M.; Witters, D. In: *Biological Effects of Electromagnetic Waves: Selected Papers of the USNC/URSI Annual Meeting, Boulder CO, October 20-23, 1975*. Sponsored by U.S. National Committee of the International Union of Radio Sciences, National Academy of Sciences (Washington, DC): Vol. II, pp. 324-337, 1976. (8 refs)

A miniature isotropic electric field probe consisting of three orthogonal dipoles (each 2.5 mm in length) with integral diode detectors was theoretically and experimentally evaluated for its capability to accurately determine electric field strengths within multilayered biologic systems. Using a well-established buried transmission line theoretic model, the antenna impedance was analyzed with respect to various implantation situations. It was demonstrated both analytically and experimentally that for deep implantation in muscle very little change ($\pm 10\%$) in probe response occurs with respect to the free space response of the probe over the frequency range of 0.915-2.45 GHz. In addition, when in very close proximity to the muscle-fat or muscle-air (worst case) boundary, no observable change in probe response occurred because of dipole impedance variations. A lack of significant electric field perturbation by the probe itself was also demonstrated in a muscle-equivalent slab.

5567 A NEW SYSTEM FOR INVESTIGATING NONTHERMAL EFFECT OF MICROWAVES ON CELLS. (Eng.) Lin, J. C. In: *Biological Effects of Electromagnetic Waves: Selected Papers of the USNC/URSI Annual Meeting, Boulder CO, October 20-23, 1975*. Sponsored by U.S. National Committee of the International Union of Radio Sciences, National Academy of Sciences (Washington, DC): Vol. II, pp. 350-355, 1976. (10 refs)

A fluid-filled waveguide exposure system with a micropipette sample holder has been developed to

isolate nonthermal effects of microwave radiation on mammalian cell cultures from those effects resulting from cell temperature rise. The system allows for more precise calibration of the incident and absorbed microwave energies. The capability of the system was demonstrated on Chinese hamster somatic cells irradiated for 20 min with 2,450-MHz microwave radiation at power densities ranging from 1-500 mW/cm². No significant differences were found between cells exposed to 100 mW/cm² or less and controls. At these power densities, the cell temperature stayed constant at 37°C. Clearcut cytotoxic effects were seen however when an incident power density of 500 mW/cm² (1,100 mW/g absorbed) was applied. The cells exposed to this power density had a temperature rise of about 5°C due to the limited pumping capacity of the exposure system's circulator. Qualitatively, a slower growth rate, changes in cell structures, and differences in the size of individual colonies after a 12-day incubation period were observed in cells exposed to 500 mW/cm² of radiation. Irradiated cells also showed increased vacuolization in addition to morphologic transformations. In more recent experiments in which a constant temperature circulator with refrigeration capability was used to control the temperature of the exposure system's bathing solution to within ± 1 °C, irradiated cells did not show any morphologic change. With further improvements in the apparatus, the exposure system may serve as a prototype for future studies of the thermal and nonthermal interaction mechanisms of microwave-induced biologic changes in living organisms at the cellular level.

5568 MEASUREMENT OF ELECTRIC AND MAGNETIC FIELD STRENGTHS FROM INDUSTRIAL RF POWER SOURCES. (Eng.) Conover, D. L.; Parr, W. H.; Sensintaffar, E. L.; Murray, W. E. In: *Biological Effects of Electromagnetic Waves: Selected Papers of the USNC/URSI Annual Meeting, Boulder CO, October 20-23, 1975*. Sponsored by U.S. National Committee of the International Union of Radio Sciences, National Academy of Sciences (Washington, DC): Vol. II, pp. 356-362, 1976. (9 refs)

Measurements of radio frequency (RF: 15-40.68 MHz) electric and magnetic field strength exposures generated by power sources having application in the textile, lumber, and plastics industries are presented. Measurements were taken at distances less than 1 m from sources where operating personnel were located using monitors that were constructed and calibrated for near-field exposure measurements. A comparison of the field strength exposures with the American National Standards Institute C95.1-1974 RF/Microwave Personnel Exposure Standard radiation exposure guides revealed that 90% of the sources exceeded the electric field strength guide of 200 V/m and 80% of the sources exceeded the magnetic field strength guide of 0.5 A/m. These guides were exceeded by factors as high as five for the electric field and by as high as 25 for the magnetic field. These measurements demonstrate that a very significant magnetic field strength personnel

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exposure can be completely neglected, if commercial far-field power density monitors (with dipole antenna elements) that respond only to the electric field component of an RF field are used. It is important not to neglect the magnetic field strength component of the RF field because magnetic field-induced power absorption (in biologic phantom models of man) predominates for near-field exposure conditions.

5569 **BROADCAST RADIATION: A SECOND LOOK.**
(Eng.) Tell, R. A.; Janes, D. E. In: *Biological Effects of Electromagnetic Waves: Selected Papers of the USNC/URSI Annual Meeting*, Boulder CO, October 20-23, 1975. Sponsored by U.S. National Committee of the International Union of Radio Sciences, National Academy of Sciences (Washington, DC): Vol. II, pp. 363-388, 1976. (47 refs)

Data obtained from field measurements and theoretic calculations on power densities near radio and television broadcast stations are reviewed. Hazard surveys at various broadcast installations indicate that broadcast stations are a major source of radio frequency exposure in the environment, and if the circumstances are right, environmentally significant exposures ($1-10 \text{ mW/cm}^2$) may occur. In particular, an analysis of 326 frequency-modulated (FM) broadcast stations revealed that the maximum computed power density is about 21 mW/cm^2 for a roof top location in Oklahoma City. Moreover, 86 of these 326 stations could potentially produce a power density of 1 mW/cm^2 or higher. It is suggested that the currents and local fields on energized broadcast towers should be investigated further to determine actual exposure and absorbed dose data for personnel working on these towers. Careful consideration should also be given to work on towers or buildings immediately adjacent to high power broadcast stations, especially ultra-high-frequency television. At present, no environmental standard exists for RF or microwave exposure, although careful examination is being given to the range between 1 and 10 mW/cm^2 .

5570 **SYSTEM FOR QUANTITATIVE CHRONIC EXPOSURE OF A POPULATION OF RODENTS TO UHF FIELDS.**
(Eng.) Guy, A. W.; Chou, C-K. In: *Biological Effects of Electromagnetic Waves: Selected Papers of the USNC/URSI Annual Meeting*, Boulder CO, October 20-23, 1975. Sponsored by U.S. National Committee of the International Union of Radio Sciences, National Academy of Sciences (Washington, DC): Vol. II, pp. 389-410, 1976. (11 refs)

A system for economically exposing a large population of rodents to ultra-high frequency electromagnetic fields over long periods of time without disturbing the animals' normal laboratory living patterns is described. The system consists of a number of individual exposure cells connected through a power divider network to a single power source. The use of separate cells consisting of cylindrical waveguide sections excited with circularly polarized guided waves provides relatively

constant and easily quantifiable coupling of the fields to each animal regardless of their position, posture, and moving patterns. The standing wave ratio to each cell is sufficiently low that any number of cells can be coupled to the single power source through a power splitter without the need for isolation circuitry. For instance, a low cost 700-W microwave source built from parts of a microwave oven power supply can be used with the system to expose as many as 200 animals to an average power density as high as 10 mW/cm^2 .

5571 **MAPPING OF FREE SPACE AND SCATTERED FIELDS IN MICROWAVE DIATHERMY.** (Eng.) Kantor, G.; Bassen, H. I.; Swicord, M. L. In: *Biological Effects of Electromagnetic Waves: Selected Papers of the USNC/URSI Annual Meeting*, Boulder CO, October 20-23, 1975. Sponsored by U.S. National Committee of the International Union of Radio Sciences, National Academy of Sciences (Washington, DC): Vol. II, pp. 411-422, 1976. (3 refs)

Near-field measurements of external 2,450-MHz electric fields around a Type B microwave diathermy applicator were performed in free space and in conjunction with simulated biotissue to obtain typical maps of fields around diathermy applicators presently in clinical use. The Type B applicator was found to be relatively ineffective, since the major portion of its near-field (longitudinal) is inefficient in generating tissue heating. Also, the transverse component of the near field contributing to the heating pattern in the center was about five times lower than that at the off-center field maxima (30 mW/cm^2 and 140 mW/cm^2 , respectively). Scattered fields, which could expose unprescribed tissue to microwave radiation, were measured in conjunction with a phantom arm, and it was found that large longitudinal field components can constitute a hazard at grazing incidence; for grazing incidence, the aperture of an applicator is defined as being non-parallel to the surface of the phantom or patient. Under these conditions, the impinging longitudinal field is the main source for microwave heating since it is oriented at a shallow angle with respect to the surface of the biologic material. The above findings lead to the conclusion that for flat surface irradiation special applicator designs with minimal longitudinal field components are most desirable for optimum efficacy. Furthermore, such designs are safer since they eliminate the possibility of overexposure due to grazing incidence.

5572 **BEHAVIORAL EFFECTS OF ELECTROMAGNETIC ENERGY.** (Eng.) Frey, A. H. (Randomline, Inc., Huntingdon Valley, Pa.). In: *Symposium on Biological Effects and Measurement of Radio Frequency/Microwaves. Proceedings of a Conference held in Rockville, MD on February 18-19, 1977*. Sponsored by BRH and WHO Collaborating Center for Standardization of Protection Against Nonionizing Radiation. pp. 11-22; 1977. (6 refs)

The effect of electromagnetic energy on the behavior

of Sprague-Dawley rats was investigated. In one series of experiments, rats were exposed to continuous wave or pulsed (0.5 or 0.1 msec pulse width, 1,000 pulses/sec) electromagnetic radiation at frequencies of 1.0, 1.3, or 1.5 GHz, average power levels ranging from 0.005-0.2 mW/cm², and peak power levels of 0.05-0.2 mW/cm² during a pain-induced aggression situation. Irradiated rats exhibited a docility response relative to sham-irradiated controls in this situation, and the data suggested a positive linear relationship between the degree of docility and peak power employed. The threshold for the radiation-induced docility response was a peak power between 0.05 and 0.1 mW/cm². There were indications that continuous wave energy was not as effective as pulsed energy in eliciting docility, although rats exposed to either type of energy were significantly more docile than their sham-irradiated counterparts. In a second series of experiments, rats performing a balancing task on a rotating rod were exposed to 1-, 1.3-, or 1.5-GHz pulsed radiation (1,000 pulses/sec, 0.5 msec pulse width) at various average and peak power levels. Rats exposed to 1.3 or 1.5-GHz radiation were adversely affected compared with controls in terms of motor coordination or balance in the task, and the peak power threshold for this effect was between 0.4 and 2.8 mW/cm².

5573 FREE-OPERANT AVOIDANCE AND ESCAPE FROM MICROWAVE RADIATION. (Eng.) Monahan, J. C. (Div. Biological Effects, Bureau Radiological Health, Food & Drug Admin., Dept. Health Education & Welfare, Rockville, MD 20852); Henton, W. W. In: *Symposium on Biological Effects and Measurement of Radio Frequency/Microwaves. Proceedings of a Conference held in Rockville, MD on February 16-18, 1977*. Sponsored by BRH and WHO Collaborating Center for Standardization of Protection Against Nonionizing Radiation. pp. 23-32; 1977. (14 refs)

Studies to determine the stimulus properties of microwaves in a free-operant avoidance-escape paradigm were conducted with male CF1 mice. Experimental mice were exposed to continuous wave 2.45-GHz microwaves (averaged absorbed dose rate of 46 mW/g) paired with a 2,900-Hz tone, while sham subjects were exposed to the tone only. During the session, all mice could make responses to the exposure by interrupting a light beam, which passed through the animal holder. If no response was made, then the tone remained on for the entire session. If the subjects responded during the tone, it was terminated and remained off for 12 sec. This was considered an escape response. If the subjects responded during this tone-off period, each response would delay the onset of tone for 12 sec. This was considered an avoidance response. Sham-irradiated mice tended to have very low response rates or only occasional bursts of responding; whereas, irradiated mice, whose responses either permitted them to avoid or escape the radiation, responded consistently throughout the experimental session. Furthermore, sham-irradiated mice had a much higher interresponse time than irradiated mice who had mean exposure on-times of less than 20 sec. Irradiated mice were categorized by their response patterns into escape

animals, avoidance animals, and mixed response animals. For a given subject, this response pattern remained consistent across experimental sessions. These data show that microwave radiation can serve as a noxious stimulus that will maintain an active instrumental avoidance or escape behavior over repeated experimental sessions.

5574 MICROWAVE ABSORPTION AND TASTE AVERSION AS A FUNCTION OF 915 MHZ RADIATION. (Eng.) Monahan, J. C. (Div. Biological Effects, Bureau Radiological Health, Food & Drug Admin., Dept. Health Education & Welfare, Rockville, MD 20852); Henton, W. W. In: *Symposium on Biological Effects and Measurement of Radio Frequency/Microwaves. Proceedings of a Conference held in Rockville, MD on February 16-18, 1977*. Sponsored by BRH and WHO Collaborating Center for Standardization of Protection Against Nonionizing Radiation. pp. 34-40; 1977. (17 refs)

Individually housed male Sprague-Dawley rats were divided into four subgroups of eight rats each and were exposed while restrained in a waveguide to 915-MHz continuous wave radiation at forward power levels of 19.0, 9.1, 5.0, or 0.0 (sham) W, respectively, immediately following 15 min of access to a 10% sucrose solution to test the effect of microwave exposure on taste aversion. Absorption of microwave energy was relatively unchanged throughout a 15-min exposure to a forward power of 5.0 W; whereas, microwave absorption progressively decreased during exposures to forward power levels of 9.1 and 19.0 W. When each rat was again given access to sucrose 24 hr later, there was no indication of a conditioned taste aversion in irradiated rats when compared with sham-irradiated controls. These results do, however, suggest a temporal pattern in the absorption of microwave energy by living organisms. They also suggest that the calculated energy absorption may not be a complete characterization of microwave effects when averaged across exposure duration; rather, they suggest a systematic alteration in energy absorption within exposure conditions that may require a sequential analysis of time and intensity exposure parameters. Moreover, the microwave attenuation effect may be related to elicited orienting behavior within the microwave field, which minimizes energy absorption and maximizes energy reflection suggesting that actual absorbed microwave energy may be a dependent variable characterizing the subject's behavior rather than an independent variable exclusively defining microwave properties.

5575 BEHAVIORAL PROTOCOLS AND PRELIMINARY OBSERVATIONS OF CHICKS EXPOSED TO WEAK AMPLITUDE MODULATED 450 MHZ FIELDS. (Eng.) Medici, R. G. (Environmental Neurobiology Lab., Brain Res. Inst., UCLA, Los Angeles, CA); Sagan, P. M. In: *Symposium on Biological Effects and Measurement of Radio Frequency/Microwaves. Proceedings of a Conference held in Rockville, MD on February 16-18, 1977*. Sponsored by BRH and WHO Collaborating Center for Standardization of Protection Against Nonionizing Radiation. pp. 41-53; 1977. (15 refs)

CURRENT LITERATURE

A programmatic approach for investigating the effects of weak amplitude modulated 450-MHz electric fields on the behavior of experimental animals is described along with some preliminary results. Based on experiments dealing with the effects of weak extremely low frequency fields on the behavior of primates, a series of studies has been designed to assay the behavioral effects of weak amplitude modulated 450-MHz fields in neonatal chicks and wild mallard ducklings. The approach is three dimensional. Tests will be done at different power levels, with special attention being given to the possibility of voltage windows. Tests will be done at different modulation frequencies, with special attention being given to biologically relevant frequencies, and tests will be made across increasingly complex time-based schedules of reinforcements. Preliminary studies with neonatal chicks exposed for 20 min to a 450-MHz field (5 mW/cm^2) amplitude modulated at 3 or 16 Hz with a fixed time schedule of reinforcement suggest that simple activity measures are inadequate assays of possible weak effects; whereas, latency measures are sensitive to the presence of the field. At both modulation frequencies, the 20-min exposure to the field was associated with markedly reduced latencies. Further testing is being done to confirm these preliminary observations.

5576 MICROWAVE HYPERTERMIA AND VISUALLY EVOKED POTENTIALS: PRELIMINARY OBSERVATIONS OF GUINEA PIGS. (Eng.) Justesen, D. R. (Lab. Experimental Neuropsychology, Veterans' Admin. Hosp., Kansas City, MO); Bruce-Wolfe, V. In: *Symposium on Biological Effects and Measurement of Radio Frequency/Microwaves. Proceedings of a Conference held in Rockville, MD on February 16-18, 1977*. Sponsored by BRH and WHO Collaborating Center for Standardization of Protection Against Nonionizing Radiation. pp. 54-61; 1977. (13 refs)

The effect of microwave hyperthermia on visually-evoked potentials in guinea pigs was investigated. Latencies of an early component (N_1) of the visually evoked electrocortical response (VER) of two guinea pigs were observed as a function of body temperature, which was elevated by brief exposures to microwave radiation. Body temperature elevation was achieved by exposing the animals to 2,450-MHz microwaves modulated as a half-wave sinusoid at 60 Hz and applied at a rate of 30 mW/g until the rectal temperature reached 42°C. Each animal underwent a minimum of 10 radiation treatments with accompanying observations of the VER. Each treatment was separated by a minimum of 23 hr. A U-shaped curvilinear relation was observed in which the N_1 latency decreased as temperature fell from 41 to 39.5°C and then increased as body temperature continued to fall to 38°C. The temperature for optimal rates of neural processing of sensory information may therefore be 1 to 2°C above that of the resting norm. Barring artifact, the inverted U-function may be taken as evidence of optimization of rates of neural activity and information processing as the guinea pig's body temperature is normally elevated to temperatures near 39.5°C during behavioral hyperarousal.

5577 BROADBAND MEASUREMENTS OF DIELECTRIC PROPERTIES. (Eng.) Swicord, M. L. (Bureau Radiological Health, Food & Drug Admin., Dept. Health Education and Welfare, Rockville, MD 20852). In: *Symposium on Biological Effects and Measurement of Radio Frequency/Microwaves. Proceedings of a Conference held in Rockville, MD on February 16-18, 1977*. Sponsored by BRH and WHO Collaborating Center for Standardization of Protection Against Nonionizing Radiation. pp. 71-80; 1977. (6 refs)

A method for measuring the dielectric constant of liquid or gel samples over a frequency range of 0.5-18 GHz was developed to obtain a possible parameter for predicting the existence of frequency selective biologic effects during electromagnetic field exposures. The method avoids solutions to transcendental equations, and its solution is independent of sample thickness. A limitation of the method is that the total useful frequency range is constrained by the practical size of sample construction. Since samples can be constructed as thin as 2 mm, the upper practical frequency range is well above 18 GHz. Samples much longer than 20 cm are impractical, suggesting a lower frequency limitation of about 200 MHz or possibly 500 MHz for most dielectrics of interest. The method is particularly adaptable for use with automated systems but can also be used with slotted lines. Data on various samples (air, lauric acid, plexiglas, bone, selastic rubber, and muscle) were obtained using an automatic network analyzer and were found to agree with slotted line data and expected results.

5578 QUANTITATION OF MICROWAVE BIOLOGICAL EFFECTS. (Eng.) Chou, C-K. (Bioelectromagnetics Res. Lab., Dept. Rehabilitation Medicine RJ-30, Univ. Washington Sch. Medicine, Seattle, WA); Guy, A. W. In: *Symposium on Biological Effects and Measurement of Radio Frequency/Microwaves. Proceedings of a Conference held in Rockville, MD on February 16-18, 1977*. Sponsored by BRH and WHO Collaborating Center for Standardization of Protection Against Nonionizing Radiation. pp. 81-103; 1977. (23 refs)

Research on microwave biological effects supported by the Bureau of Radiological Health and performed in the Bioelectromagnetics Research Laboratory of the University of Washington School of Medicine over the past 5 yr is described. In addition to the experimental development of quantitative methods involving thermograms and phantom materials, theoretic studies were performed to achieve a better understanding of the relationships between frequency, dielectric properties, and the size and shape of objects. Neurophysiologic experiments were performed with emphasis on delineating the mechanisms of microwave effects. Thermographic and phantom models of man were used to determine energy absorption in man exposed to common sources of electromagnetic energy. The problem of using metal electrodes for electrophysiologic recordings during microwave exposure was demonstrated, and an alternative technique using high resistance carbon elec-

trodes was developed. Techniques for chronically exposing animals in a circularly polarized field at minimal cost were also developed. Work was also performed on the development of safe methods and the evaluation of hazards for the application and monitoring of electromagnetic energy in diathermy practice. Both *in vivo* and *in vitro* experiments demonstrated that the effect of acute exposure to continuous wave and/or pulsed microwaves on the electrophysiologic properties of the nervous system is thermal in nature. The threshold for a latency shift in the thalamic evoked responses appears to fall between 2.5 and 5.0 W/kg specific absorption rate (SAR) in exposed tissues, which is about 25-50% of the normal metabolic rate of brain tissue. When extrapolated to humans, the incident power density required to produce an equivalent SAR in the head of man is between 10 and 25 mW/cm². Studies on microwave auditory effects provided strong evidence that the mechanism of microwave hearing is electro-mechanical in nature. Studies on diathermy safety and applicator design revealed that the 900-MHz direct contact applicator not only provides better therapeutic heating but also produces less leakage than the existing 2,450-MHz "C" director. Thermo-graphic measurements of man exposed to very high frequency radiation indicated that peak-measured SAR values may exceed the estimated averaged values by more than an order of magnitude in various locations of the body.

5579 NEAR-FIELD MEASUREMENTS OF RF FIELDS.
(Eng.) Ruggera, P. S. (Div. Electronic Products, Bureau Radiological Health, Food & Drug Admin., Dept. Health Education & Welfare, Rockville, MD 20852). In: *Symposium on Biological Effects and Measurements of Radio Frequency/Microwaves. Proceedings of a Conference held in Rockville, MD on February 16-18, 1977*. Sponsored by BRH and WHO Collaborating Center for Standardization of Protection Against Nonionizing Radiation. pp. 104-116; 1977. (1 ref)

Near field electric and magnetic field data (along with their equivalent far field power density) are presented for radio frequency sealers, electro-surgical units, and citizen band (CB) radios. In all three cases, typical operating conditions were found in which the currently held, though voluntary, American National Standards Institute standard of 10 mW/cm² was exceeded. The most widely used source of radio frequency radiation emissions, and possibly the one with the greatest potential for public exposure, is the CB radio operating at 27 MHz. Electric fields equivalent to a free space power density of 18.2 mW/cm² were measured at 12 cm from a hand-held CB unit operating at the legal maximum output power of 4 W. A point of major concern in CB is the widespread, though illegal (FCC regulations), use of linear amplifiers to achieve an output power of up to 1,000 W. It was also demonstrated that it is necessary to measure both the electric and the magnetic field for assessing potential hazards of radio frequency radiation; conventional power density measurements give quite different results.

5580 ELECTRIC FIELD MEASUREMENTS WITHIN BIOLOGICAL MEDIA. (Eng.) Cheung, A. Y. (Inst. Physical Science & Technology, Univ. Maryland, College Park, MD). In: *Symposium on Biological Effects and Measurement of Radio Frequency/Microwaves. Proceedings of a Conference held in Rockville, MD on February 16-18, 1977*. Sponsored by BRH and WHO Collaborating Center for Standardization of Protection Against Nonionizing Radiation. pp. 117-135; 1977. (9 refs)

The use of an implanted miniature isotropic electric field probe for the direct measurement of electric fields at microwave frequencies (0.915-2.45 GHz) was theoretically and experimentally explored. Using a model of buried antenna transmission line and insulated dipole, the antenna impedance was analyzed with respect to various implantation situations. The use of a small insulated dipole as the detection element enables the probe's response to an electric field to remain relatively constant with regard to the electrical properties of the media surrounding the probe. Material inhomogeneities and temperature changes do not affect this relationship, even though these produce significant variations occurring in the magnitude of the dielectric constant of the biologic media. Therefore, a properly designed probe may be calibrated in free space and then used as an implantable probe in infinite media without spatial calibration. Using this approach, errors of less than $\pm 10\%$ were encountered when experimentally measured fields in a large muscle-equivalent slab were compared with theoretically computed field strengths induced by plane wave irradiation of the slab at 0.915-2.45 GHz. In addition, when in very close proximity to a muscle-fat or muscle-air (worst case) boundary, no significant change occurred in the probe response because of dipole impedance variations. This is unique to the specific probe design utilized in which the diode detector impedance is much higher than the antenna impedance, thus eliminating dipole-boundary interaction.

5581 INTERNAL DOSIMETRY AND EXTERNAL MICROWAVE FIELD MEASUREMENTS USING MINIATURE ELECTRIC FIELD PROBES. (Eng.) Bassen, H. (Div. Electronic Products, Bureau Radiological Health, Food & Drug Admin., Dept. Health Education & Welfare, Rockville, MD 20852). In: *Symposium on Biological Effects and Measurement of Radio Frequency/Microwaves. Proceedings of a Conference held in Rockville, MD on February 16-18, 1977*. Sponsored by BRH and WHO Collaborating Center for Standardization of Protection Against Nonionizing Radiation. pp. 136-151; 1977. (5 refs)

An optically-linked electromagnetic probe system with a frequency range of 0.2-12 GHz and a measurement range of 20 μ W/cm² to 20 mW/cm² equivalent was designed for specialized laboratory measurements where present probes are not appropriate due to their physical size or hard-wired readout. The basic elements of the probe are three orthogonal miniature dipoles (2.5 mm long), each on its own substrate. A pair of high-resistance, thin film

leads (97,000 ohms/cm) transmits the detected signal from the antenna to a second, lower-resistance pair of long leads. The probe's small size provides the maneuverability and high spatial resolution required to map fields with steep spatial gradients or those in confined areas, such as, animal exposure restrainers. A fiber optically-linked telemetry system provides radiofrequency interference immunity and enhances accuracy below 1 GHz by eliminating cable scatter. The absolute accuracy of the probe is ± 1 dB at calibration points. The probe system was tested at a frequency of 450 MHz as a field mapping device to evaluate an animal exposure chamber. The small size of the probe provided good spatial resolution of the fields and allowed the mapping of areas within the animal restrainers and the chamber to be performed easily, even in small confined areas. The probe was also used to measure fields within simulated and actual biologic specimens. Although the cylindrical cross section of the probe (4-5 mm) made implantation studies in a cat's brain impracticable because of the possibility of extensive tissue damage and bleeding, a preliminary design with a cross-section of about 2 mm has been developed, which should allow for more flexibility in both the selection of implantation sites and the elimination of the complete immobilization of an animal during irradiation.

5582 A FINITE ELEMENT TECHNIQUE FOR CALCULATING INDUCED INTERNAL FIELDS AND POWER DEPOSITION IN BIOLOGICAL MEDIA OF COMPLEX IRREGULAR GEOMETRY EXPOSED TO PLANE WAVE ELECTROMAGNETIC RADIATION. (Eng.) Neuder, S. M. (Div. Electronic Products, Bureau Radiological Health, Food & Drug Admin., Dept. Health Education & Welfare, Rockville, MD 20852). In: *Symposium on Biological Effects and Measurement of Radio Frequency/Microwaves. Proceedings of a Conference held in Rockville, MD on February 16-18, 1977*. Sponsored by BRH and WHO Collaborating Center for Standardization of Protection Against Nonionizing Radiation. pp. 170-190; 1977. (7 refs)

A mathematic technique for calculating induced field distributions within irregularly shaped biologic systems with complex internal structure is presented. The technique makes use of the variational calculus, the method of trial solutions, and the finite element method. The method is applied to a triple-layered (bone, muscle, fat) irregularly-shaped model of the human thigh exposed to 433 MHz plane-wave radiation, and the results show high electric field values on the irradiated face with a rapid decrease as one progresses in the direction of propagation.

5583 COMPARISON OF CALCULATED ABSORBED DOSE RATE DISTRIBUTIONS IN PHANTOM HEADS EXPOSED TO 2450 MHz AND 915 MHz PLANE WAVE AND SLOT SOURCES. (Eng.) Ho, H. S. (Div. Biological Effects, Bureau Radiological Health, Food & Drug Admin., Dept. Health Education & Welfare, Rockville, MD 20852). In: *Symposium on Biological Effects and Measurement of Radio Frequency/Microwaves. Proceedings of a Conference held in Rockville, MD on February 16-18, 1977*. Sponsored by BRH and WHO Col-

laborating Center for Standardization of Protection Against Nonionizing Radiation. pp. 191-200; 1977. (5 refs)

Calculations of absorbed dose rate patterns in 7-cm and 3.3-cm phantom heads simulated by dielectric spheres are made for plane wave (whole body) and slot source (partial body) exposures to 2,450-MHz and 915-MHz microwaves. The results indicate completely different patterns of microwave energy absorption for these two exposures. Plane wave exposure results in a deeper penetration, while the slot source exposure results in a larger maximum absorbed dose rate. The penetration depth due to the slot source increases with increased slot width. For a given aperture size, the change in penetration depth is small when the source frequency decreases from 2,450 MHz to 915 MHz because of the counter-balancing effects of increased skin depth and decreased effective slot size. It is questionable as to how close the results of this investigation simulate the real life exposure of human heads to microwave slot sources. One parameter of concern is, for example, the effective slot size of the exposure field from a leaking microwave oven door as a function of distance from the door. Changes in absorption due to the irregular geometry of the human head are another concern.

5584 CHANGE IN AVERAGE ABSORBED DOSE RATE OF A GROUP OF MICE UNDER REPEATED EXPOSURE TO 915 MHz MICROWAVE RADIATION. (Eng.) Ho, H. S. (Div. Biological Effects, Bureau Radiological Health, Food & Drug Admin., Dept. Health Education & Welfare, Rockville, MD 20852); Pinkavitch, F.; Edwards, W. P. In: *Symposium on Biological Effects and Measurement of Radio Frequency/Microwaves. Proceedings of a Conference held in Rockville, MD on February 16-18, 1977*. Sponsored by BRH and WHO Collaborating Center for Standardization of Protection Against Nonionizing Radiation. pp. 201-215; 1977. (1 ref)

Mice were exposed repeatedly to 915-MHz continuous wave microwave radiation to investigate possible changes in average absorbed dose rate as a function of exposure duration. In preliminary experiments where 14 female mice were irradiated with a forward power of 2.5 W for 6 hr/day over 4 days, resulting in a mean average absorbed dose rate of 3.4 mW/g, there was no reduction in microwave energy absorption during irradiation. However, when two groups of mice (14 males and 14 females) were irradiated with a forward power of 5 W for 8 hr/day during alternate working days of the week for a total period of 2 mo, a reduction of energy absorption with exposure duration was observed. For male mice, the microwave energy absorption decreased from a mean value of 6.9 mW/g during hr 1 to a low of 4.3 mW/g during hr 6 of irradiation and then increased slightly to 4.9 mW/g during hr 8 of exposure. For female mice, the energy absorption changed in a similar manner, with mean values of 7.3, 4.6, and 4.9 mW/g during hr 1, 6, and 8, respectively. For both male and female mice, the average absorbed dose rate seemed lower in the first few sessions

than in the rest of the sessions. The changes in energy absorption could not be accounted for by changes in air temperature or body weight increase during the exposure sessions. These observations indicate possible problems in dosimetry determination for animal irradiation systems where parameters for determining the average absorbed dose rate are not monitored during the irradiation.

- 5585 THE DESCRIPTION OF A SYSTEM TO IRRADIATE CELLS IN CULTURE WITH MICROWAVES. (Eng.) Rabinowitz, J. R. (New York Univ. Medical Center, Inst. Environmental Medicine, New York, NY); Oicerst, R. B.; Mumford, W. W. In: *Symposium on Biological Effects and Measurement of Radio Frequency/Microwaves. Proceedings of a Conference held in Rockville, MD on February 16-18, 1977*. Sponsored by BRH and WHO Collaborating Center for Standardization of Protection Against Nonionizing Radiation. pp. 216-229; 1977. (9 refs)

A system for irradiating biologic preparation and measuring specific molecular functions in a temperature-controlled environment is described. The biologic samples are placed in Teflon tubes whose surface temperature is controlled by inserting the tube into a jacket through which a coolant (Dodecane) is pumped. The use of the coolant also provides a method for measuring the power absorbed by the sample using matched thermistors at the input and output ports of the jacket. The waveguide irradiation system employs a tuning system so that almost all of the incident energy is absorbed by the sample and very little energy is reflected. The purpose of the described apparatus is to yield a response function that is dependent on the bath temperature, the rate at which energy is absorbed from the field, and the time from the beginning of the exposure. The temperature variation within the sample can have a significant effect on the biologic response measured. For example, with glucose efflux from human red blood cells at an energy absorption rate of 200 mW/cm³, the temperature variation was found to cause a 12-20% increase in biologic response. For adenosine triphosphatase activity under the same conditions, the temperature variation was found to cause a 40-70% increase in biologic response. The effect of the temperature variation within the sample is highly dependent on the type of biologic response being investigated and must be taken into account or else it will lead to erroneous results.

- 5586 NEW TYPES OF MICROWAVE DIATHERMY APPLIATORS--COMPARISON OF PERFORMANCE WITH CONVENTIONAL TYPES. (Eng.) Kantor, G. (Div. Electronic Products, Bureau Radiological Health, Food & Drug Admin., Dept. Health Education & Welfare, Rockville, MD 20852) In: *Symposium on Biological Effects and Measurement of Radio Frequency/Microwaves. Proceedings of a Conference held in Rockville, MD on February 16-18, 1977*. Sponsored by BRH and WHO Collaborating Center for Standardization of Protection Against Nonionizing Radiation. pp. 230-247; 1977. (11 refs)

A comparison of the performance of new types of microwave (2.45 GHz) diathermy applicators (direct contact type) with that of conventional spaced applicators is presented. Heating patterns induced in planar phantoms of simulated fat and muscle by both types of applicators were compared. The new direct contact type applicators provided for more uniform heating in the center of the temperature profiles than did conventional spaced applicators presently in general clinical use. Electric field measurements showed that the leakage radiation of commercially available direct contact applicators is less than 5 mW/cm² per 100 W of forward power at a spacing of 5 cm from the aperture-phantom boundary, while scattered field levels for loaded spaced applicators can typically be 30 mW/cm² per 100 W of forward power at a distance of 13 cm in front of the aperture. Among four types of new direct contact applicators tested (square aperture horn, circular waveguide, loaded rectangular waveguide, and circular aperture horn), leakage was particularly low with the circular aperture horn design, being a negligible 0.8 mW/cm²/100 W. It appears that unwanted irradiation of the diathermy machine operator and irradiation of unprescribed tissue of the patient are much more easily controlled with direct contact applicators than with spaced applicators.

- 5587 BIOLOGICAL EFFECTS OF MICROWAVES ON THE PUPAE OF *TENEBRIOS MOLITOR*. (Eng.) Green, D. R. (Dept. Electrical Engineering, Washington Univ., St. Louis, MO); Rosenbaum, F. J.; Pickard, W. F. In: *Symposium on Biological Effects and Measurement of Radio Frequency/Microwaves. Proceedings of a Conference held in Rockville, MD on February 16-18, 1977*. Sponsored by BRH and WHO Collaborating Center for Standardization of Protection Against Nonionizing Radiation. pp. 253-261; 1977. (9 refs)

Pupae of *Tenebrio molitor* were exposed to 9-GHz microwave radiation to demonstrate that microwave-induced teratogenesis is associated at power levels far below those at which obvious thermal damage occurs. Microwave-induced teratogenesis was observed at power levels of 20 mW and higher. At 320 mW of power, exposure to 9-GHz radiation for 2 hr resulted in 100% mortality, while at 160 mW for 2 hr, only 10% mortality was observed, indicating that the onset of lethal (presumably) thermal effects occurs within this power interval. An average temperature rise of less than 2 C at 20 mW of incident power at 9 GHz is expected from previous thermocouple measurements, and at 320 mW a temperature rise of about 30 C above ambient is thus expected; this is high enough for macromolecular heat denaturation. Therefore, the effects observed at the 20 mW power level are probably no thermal in the usual sense of the word. It was also observed that previously traumatized pupae are more likely to suffer damage from microwave exposure than those that show no signs of abnormality.

CURRENT LITERATURE

Biological Effects of Nonionizing Electromagnetic
Radiation 11(4), June, 1978

- 5588 NEUROENDOCRINE RESPONSES IN THE RAT AND DOG EXPOSED TO 2450 MHz (CW) MICROWAVES. (Eng.) Michaelson, S. M. (Non-Ionizing Radiant Energy Facility, Dept. Radiation Biology and Biophysics, Univ. Rochester, Rochester, NY); Guillet, R.; Lotz, W. G.; Lu, S-T.; Magin, R. L. In: *Symposium on Biological Effects and Measurements of Radio Frequency/Microwaves. Proceedings of a Conference held in Rockville, MD on February 16-18, 1977*. Sponsored by BRH and WHO Collaborating Center for Standardization of Protection Against Nonionizing Radiation. pp. 263-279; 1977. (21 refs)

Hormone measurements were made in mongrel dogs subjected to 120-Hz modulated 2,450-MHz microwave irradiation of the head or thyroid and in Hood Evans rats subjected to whole-body 2,450-MHz continuous wave irradiation to investigate neuroendocrine responses to microwave exposure. In the rat studies, exposures of 30 and 60 min were performed at average incident power densities of 13, 20, 30, 40, 50, and 60 mW/cm² or for 120 min at 13, 20, 30, or 40 mW/cm². Cranial exposure of the anesthetized dog to incident power densities of 20 mW/cm² to 100 mW/cm² for 1 hr revealed that body temperature increases can occur at sites other than within the electromagnetic field. Changes in endocrine function and hormone levels occurred in both rats and dogs acutely exposed to certain power-density/time durations of 2,450-MHz microwave radiation. The effects were transient and were related to the temperature increase of the individual gland or hypothalamic-hypophyseal responsiveness as a result of increased body temperature. Localized microwave heating in dogs increased the release rate of thyroxine and triiodothyronine from the thyroid, and this increase was independent of stimulation from the hypothalamus and pituitary gland. The specific absorption rate in the dog thyroid gland necessary to cause a 2 C temperature rise (the minimum temperature for stimulating thyroid gland secretion) was estimated to be 58 W/kg or approximately four times the metabolic rate of dog thyroid tissue. The exposure of rats to 2,450-MHz continuous wave whole body radiation at thermogenic power density/time durations resulted in changes in plasma corticosterone, growth hormone, and thyroid hormone levels. These effects were transient, disappearing within 15-30 min after a 1-2 hr exposure. A power density of 20-30 mW/cm² appears to be the transitional range for pituitary-adrenal activation in the rat.

- 5589 THE EFFECT OF REPETITIVE PRENATAL LOW-LEVEL MICROWAVE EXPOSURE ON DEVELOPMENT IN THE RAT. (Eng.) Shore, M. L. (Div. Biological Effects, Bureau Radiological Health, Food & Drug Admin., Dept. Health Education & Welfare, Rockville, MD 20852); Felten, R. P.; Lamanna, A. In: *Symposium on Biological Effects and Measurement of Radio Frequency/Microwaves. Proceedings of a Conference held in Rockville, MD on February 26-18, 1977*. Sponsored by BRH and WHO Collaborating Center for Standardization of Protection Against Nonionizing Radiation. pp. 280-289; 1977. (6 refs)

Time-mated Sprague Dawley rats were exposed to low-level 2,450-MHz microwave radiation for 5 hr/day

from day 3 through day 19 of gestation at an average exposure level of 10 mW/cm² to determine the effect of such exposures on the development of the offspring. One group of 12 rats was positioned parallel to the electric vector of the microwave field, while another group of 12 rats was positioned parallel to the magnetic vector of the field. Following sham or microwave exposure, the animals were allowed to deliver normally. When relative brain and body weights were determined 2-15 days postpartum, the values were consistently lower (.950 ± 0.11 and .922 ± 0.020, respectively) in offspring from rats oriented parallel to the electric field than in offspring from controls (1.000 ± 0.006 and .993 ± 0.013, respectively). Litter size did not appear to be affected by either of the above exposure orientations. The total number of dead offspring and the number of litters with mortality appeared to be higher for both exposed groups of rats than for controls; however, no significance can be attached to this observation since the experiment was not designed to evaluate postnatal survival or mortality.

- 5590 LIGHT AND ELECTRON MICROSCOPIC OBSERVATIONS ON THE BLOOD-BRAIN BARRIER AFTER MICROWAVE IRRADIATION. (Eng.) Albert, E. N. (George Washington Univ., Medical Center, Washington, DC). In: *Symposium on Biological Effects and Measurement of Radio Frequency/Microwaves. Proceedings of a Conference held in Rockville, MD on February 16-18, 1977*. Sponsored by BRH and WHO Collaborating Center for Standardization of Protection Against Nonionizing Radiation. pp. 294-304; 1977. (13 refs)

Chinese hamsters were irradiated with continuous wave 2,450-MHz microwaves at a power density of 10 mW/cm² for 2 and 8 hr for 1 day to investigate the effect of acute low-level microwave exposure on the blood-brain barrier. Light and electron microscopic observations revealed that such exposures caused alterations in the permeability of the blood-brain barrier to horseradish peroxidase (HRP) in some vessels. The altered permeability of the microvasculature did not appear to be confined to any particular region of the brain. These observations apply only to molecules of 40,000 molecular weight or less (HRP molecular weight is 40,000), since larger molecules were not tested in this experiment. Although the exact mechanisms leading to the altered permeability are not clear, the thermal effect of microwaves was not considered to be significant, since the power density was 10 mW/cm² and the exposure was of short duration. Little or no transport of HRP via interendothelial junctions was observed. There were increased HRP-filled pinocytic vesicles in endothelia of microwave-irradiated animals, and in addition, some endothelial cells seemed to be filled with HRP. This could be due to toxic effects of HRP, but this phenomenon was not seen in control animals. Whatever the reason for the cytoplasmic infiltration or toxic effect, microwaves may have rendered these cells more vulnerable to HRP. These observations suggest that transendothelial transport of large molecules may be initiated or enhanced by microwave irradiation.

- 5591 CALCIUM BINDING IN CEREBRAL TISSUE. (Eng.) Bawin, S. M. (Environmental Neurobiology Lab., Brain Res. Inst., Univ. California, Los Angeles, CA); Adey, W. R. In: *Symposium on Biological Effects and Measurement of Radio Frequency/Microwaves. Proceedings of a Conference held in Rockville, MD on February 16-18, 1977*. Sponsored by BRH and WHO Collaborating Center for Standardization of Protection Against Nonionizing Radiation. pp. 305-313; 1977. (11 refs)

The possible effects of weak, extremely low frequency (ELF) and amplitude modulated radio frequency (RF) fields on the calcium exchange between isolated nervous tissue from cats and neonate chicks and a bathing physiologic solution were investigated. The release of preincubated calcium ion from isolated chick forebrain was significantly increased after exposure to 147-MHz RF fields amplitude modulated at frequencies between 9 and 20 Hz in comparison with nonirradiated samples. A maximal increase (18%) was seen at a modulation frequency of about 16 Hz. No differences in calcium efflux were seen between chick muscles exposed to 6 and 16-Hz modulation frequencies and control samples. Experiments with ELF fields confirmed the frequency sensitivity of the tissue response seen with modulated RF fields. Significant decreases in calcium ion from chick and cat brain tissues were observed following exposures to fields of 10 and 56 V/m at frequencies of 6 and 16 Hz. Other frequencies tested (1, 32, and 75 Hz) and other field amplitudes (1, 5, and 100 V/m) did not induce changes in calcium efflux. Muscle tissue did not react to field stimulation (20 V/m, 16 Hz). The brain tissue response to ELF fields appeared to be significant only in a field amplitude window between 10 V/m and less than 100 V/m. The exposure of chick forebrain to 450-MHz fields for 20 min at an amplitude of 1 mW/cm² and a modulation frequency of 16 Hz resulted in a marked increase in the release of preincubated calcium in comparison with control samples. In contrast, 2 mW/cm² fields failed to induce measurable changes in efflux. Two other experiments conducted with 16 Hz fields at an intensity of 5 mW/cm² confirmed the results obtained at an intensity of 2 mW/cm², while three exposures of 10 samples to 0.5 mW/cm² fields (16 Hz) produced a major increase in calcium efflux. Overall, the results indicate that cerebral tissue responds to field stimulations contained within amplitude and frequency windows and that skeletal muscles do not respond to stimulations affecting the calcium exchanges in brain tissue.

- 5592 VESTIBULO-COCHLEAR SINGLE UNIT RESPONSES TO MICROWAVE RADIATION. (Eng.) Lebovitz, R. M. (Univ. Texas Health Science Center at Dallas, Dallas, TX); Seaman, R. L. In: *Symposium on Biological Effects and Measurement of Radio Frequency/Microwaves. Proceedings of a Conference held in Rockville, MD on February 16-18, 1977*. Sponsored by BRH and WHO Collaborating Center for Standardization of Protection Against Nonionizing Radiation. pp. 314-333; 1977. (23 refs)

Vestibulo-cochlear single unit responses to 915-MHz

continuous wave and pulsed microwave radiation were studied in adult cats. The threshold for continuous wave microwave activation of vestibular units at 915 MHz was significantly above the current standards for safe exposure (above a level for significant intracranial thermogenesis). However, studies with pulse-modulated microwave radiation (pulse widths of 100-250 μ sec or longer) revealed that pulse parameters rather than average power density are a more proper independent variable for vestibulo-cochlear single unit responses to microwave radiation. Responses were observed at pulse energy densities of 4 μ J/g and lower. Overall, the response of a given single auditory unit to pulsed microwave radiation was very similar to its response to traditional acoustic click stimuli.

- 5593 CAUSES OF DEATH FOLLOWING OCCUPATIONAL EXPOSURE TO MICROWAVE RADIATION (RADAR) 1950-1974. (Eng.) Robinette, C. D. (Medical Follow-up Agency, National Res. Council, National Academy Sciences, Washington, D. C.); Silverman, C. In: *Symposium on Biological Effects and Measurement of Radio Frequency/Microwaves. Proceedings of a Conference held in Rockville, MD on February 16-18, 1977*. Sponsored by BRH and WHO Collaborating Center for Standardization of Protection Against Nonionizing Radiation. pp. 338-344; 1977.

Mortality data for 19,965 Naval enlisted occupationally exposed to microwave radiation (radar) during the period 1950-1974 are compared with those for 20,726 control enlisted not occupationally exposed to microwave radiation. There was a small but significant increase in trauma mortality in the occupationally exposed group compared with controls, but neither mortality from all diseases nor total mortality was significantly different in the two groups. A closer examination at trauma mortality revealed that many of these deaths occurred as a result of military aircraft accidents. It is suggested that the excessive number of deaths in aircraft accidents among the occupationally exposed men resulted from the fact that a larger proportion of them later became flying officers. Mortality from malignant neoplasms, vascular lesions of the central nervous system, chronic nephritis, influenza and pneumonia, and cirrhosis was also elevated in the occupationally exposed men with respect to controls, but not significantly so in any case.

- 5594 EFFECTS OF REPEATED MICROWAVE IRRADIATIONS TO THE ALBINO RABBIT EYE. (Eng.) Hirsch, S. E. (Dept. Ophthalmology, Walter Reed General Hosp., Washington, DC); Appleton, B.; Fine, B. S.; Brown, P. V. K. In: *Symposium on Biological Effects and Measurement of Radio Frequency/Microwaves. Proceedings of a Conference held in Rockville, MD on February 16-18, 1977*. Sponsored by BRH and WHO Collaborating Center for Standardization of Protection Against Nonionizing Radiation. pp. 345-350; 1977. (3 refs)

Studies to determine the effects of repeated microwave irradiations on the New Zealand albino rabbit eye were conducted. The left eye of each animal

was exposed to 3,000-MHz continuous wave radiation for 15 min/day over 30 consecutive days at power densities of 50-500 mW/cm². Slit lamp examinations were performed daily for the first 30 days and intermittently thereafter for up to 1 yr after the exposure. Selected animals were sacrificed for light and electron microscopic examinations. Below a power level of 300 mW/cm², no ocular changes were detected. At 300 mW/cm² and above, all eyes reacted with congestion of the limbal vessels, pupillary constriction, and evidence of iritis. Posterior subcapsular iridescence (PSI) developed at an average of 17.5 days after irradiation at the 300 mW/cm² level. At 400 mW/cm², the PSI appeared at an average of 5 days, vacuoles appeared in the posterior cortex of the lens at an average of 8 days, and posterior cortical cataractous changes at an average of 10 days following irradiation. The lenticular opacities progressed but were limited to the posterior cortex during the following year of observation. No other ocular changes were noted in irradiated animals. It appears that cataractous changes are dependent on the production of local temperature elevations, which are sufficient to injure the lens' cortical cells.

5595 ARE MICROWAVE CATARACTS THERMALLY CAUSED?
(Eng.) Carpenter, R. L. (Div. Biological Effects, Bureau Radiological Health, Food & Drug Admin., Dept. Health Education & Welfare, Rockville, MD 20852); Hagan, G. J.; Donovan, G. L. In: *Symposium on Biological Effects and Measurement of Radio Frequency/Microwaves. Proceedings of a Conference held in Rockville, MD on February 16-18, 1977.* Sponsored by BRH and WHO Collaborating Center for Standardization of Protection Against Nonionizing Radiation. pp. 352-380; 1977. (31 refs)

Two series of experiments with rabbits were performed to determine whether the increase in intraocular temperature that occurs during microwave irradiation is the sole cause of the development of opacities in the posterior subcapsular cortex of the eye lens. In one experiment, the external application of heat (water bath temperature of 49 C) to the eye induced the same increase in intraocular temperature (about 6-7 C) over the same duration of time (40 min) as did a cataractogenic exposure to 2,450-MHz continuous wave microwaves (250 mW/cm²). No posterior cataracts were observed in five of six animals treated in this way. In a second series of experiments, loss of body heat was restricted by encasing the animal's ears in an insulated plastic sack through which flowed air heated to 55 C. By simultaneously irradiating one eye, it was possible to elevate both retrobulbar and rectal temperatures to levels characteristic of a cataractogenic microwave irradiation even though the microwave power applied to the eye during the 40-min exposure was as much as 25% below the 250 mW/cm² level necessary for cataract induction. Posterior cortical cataracts occurred in only 3 of 10 animals treated in this manner; whereas, cataracts should have been induced in all animals so treated if cataracts were solely of thermal origin. It is concluded that the increase in intraocular temperature occurring during microwave irradiation is not the

sole causative factor in microwave cataractogenesis. It is suggested that the factors involved in microwave-induced lens opacities include an adequate microwave power acting within a limited range of increased intraocular temperature for a certain exposure duration.

5596 HEAT-INVOKED CHANGES IN ASCORBIC ACID LEVELS ON THE RABBIT. (Eng.) Ferri, E. S. (Div. Biological Effects, Bureau Radiological Health, Food & Drug Admin., Dept. Health Education & Welfare, Rockville, MD 20852). In: *Symposium on Biological Effects and Measurement of Radio Frequency/Microwaves. Proceedings of a Conference held in Rockville, MD on February 16-18, 1977.* Sponsored by BRH and WHO Collaborating Center for Standardization of Protection Against Nonionizing Radiations. pp. 380-386; 1977. (8 refs)

The effect of microwave radiation on ascorbic acid levels in the rabbit eye was investigated to determine whether heat alone causes reduced levels of ascorbate in the aqueous humor with resultant lens decreases. Ascorbic acid levels in the vitreous humor, lens, and aqueous humor of rabbit eyes exposed to single and multiple microwave irradiations were assayed at 5 min, 30 min, 12 hr, 18 hr, 1 wk, 2 wk, and 4 wk postirradiation. Lens ascorbic acid levels appeared normal with the exception of about a 20% decrease at 1 wk postirradiation for an acute exposure; this drop was primarily coincident with the appearance of lens opacities. Ascorbate levels in the vitreous humor remained within control limits for all postirradiation assay periods. Ascorbate levels in the aqueous humor were decreased after an acute exposure, and these levels continued to decrease from 5 min after the insult until a low was reached at 1 wk postirradiation. Recovery to normal values occurred by 2 wk postirradiation, and ascorbate levels were still within control limits at 4 wk after irradiation. The eyes of rabbits were then heated without the use of microwaves, and ascorbate levels were determined. By immersing the ears of a rabbit in a hot water bath at 50 C, a temperature of about 40 C was achieved in the vitreous, and it was assumed that the aqueous temperature had also been elevated above normal. As an additional test of the action of heat on the aqueous humor, aliquots of this fluid were removed from both eyes of an anesthetized animal, and one aliquot was heated to 55 C, with both aliquots being analyzed for ascorbate. These tests demonstrated that when the aqueous humor was heated without the use of microwaves the ascorbate levels were not degraded. This tends to negate the theory that heat alone causes reduced levels of ascorbate in the aqueous humor with resultant lens decreases.

5597 SOME BIOLOGICAL EFFECTS OF HIGH INTENSITY, LOW FREQUENCY (60-HZ) ELECTRIC FIELDS ON SMALL BIRDS AND MAMMALS. (Eng.) Graves, H. B. (Dept. Biology and Poultry Science, Pennsylvania State Univ., University Park, PA). In: *Proceedings of Second Electromagnetic Compatibility Symposium and Exhibition.* Sponsored by EUREL, URSI, EMC Gp.

Int., AE-4, held in Montreux, Switzerland on June 28-30, 1977: pp. 465-468; 1977. (12 refs)

Experiments investigating the effects of high intensity, low frequency (60 Hz) electric fields on small birds and mammals are reported. Eggs from three genetic breeds of domestic fowl were exposed to 60-Hz fields ranging from 0-67.0 kV/m for 30 min on day 5 or 19 after the onset of incubation. With respect to hatchability, neither main nor interaction effects associated with the intensity of the field were significant. Effects on hatching time were significant but not consistent across breeds. In another experiment, median and mean gross motor activity was reduced when domestic chicks were exposed to 40- or 80-kV/m fields from day 1 through 22 posthatching. The exposure of boiler chicks to high intensity electric fields (up to 80 kV/m) for approximately 3 wk consistently resulted in a significant but not permanent enhancement in early growth responses. In conditioned suppression experiments with domestic pigeons who were presented with a 60-Hz field (25 kV/m) to warn them of an impending shock designed to suppress a learned key pecking activity, the subjects consistently exhibited suppression in response to the electric field warning. Domestic chicks exposed continuously for 22-24 days to 40 or 80 kV/m fields at a frequency of 60 Hz exhibited a significantly higher heart rate than did controls. Mice exposed continuously to 60-Hz electric fields in excess of 25 kV/m exhibited increased weight gain relative to controls over a 6-wk exposure period. In mice exposed to 0, 25, or 50 kV/m for 42 days, there was a general tendency for white blood cells to increase and red blood cells to decrease in response to increased field levels. It is concluded that additional research is needed to further replicate the above findings and to accurately quantify thresholds.

5598 SOME SPECIAL APPLICATIONS OF MICROWAVE
RADIOMETRY OF BIOLOGICAL SYSTEMS. (Eng.)
Bigu-del-Blanco, J. (Dept. Anatomy, Queen's Univ.,
Kingston, Ontario, Canada K7L 3N6). In: *Proceedings
of Second Electromagnetic Compatibility Symposium
and Exhibition*. Sponsored by EUREL, URSI, EMC Gp,
Int., AE-4 held in Montreux, Switzerland on June
28-30, 1977: pp. 469-475; 1977. (42 refs)

Special applications of microwave radiometry to the fields of biophysics, medicine, and biocommunications are reviewed. Specific microwave radiometric studies have been undertaken to investigate the following: semiconductive properties of living tissue; the role of microwave radiation in biocommunication; the response of living organisms to external stimuli, including microwave radiation and some drugs; and the potential applications of microwave radiometry in tumor diagnosis and in defining tumor location, damaged tissue, and regions of vascular deficiency. Measurements on humans, animals, and plants have been conducted in the frequency range of 100 MHz to 70 GHz.

5599 PERCEPTION OF STATIC FIELDS BY LIVING
ORGANISMS AND TERATOGENIC EFFECTS OF

MICROWAVES. (Eng.) d'Ambrosio, G. (Istituto Eletrotecnico, Universita di Napoli, Naples, Italy); La Manna, V. In: *Proceedings of Second Electromagnetic Compatibility Symposium and Exhibition*. Sponsored by EUREL, URSI, EMC Gp, Int., AE-4 held in Montreux, Switzerland on June 28-30, 1977. pp. 477-482; 1977. (8 refs)

Experiments investigating the perception of static electric and magnetic fields by larvae of *Tenebrio molitor* and the teratogenic effects of microwaves on pupae of *Tenebrio molitor* are reported. When the distribution of larvae in a non-uniform electric field was studied, fields only a few times greater than the earth's natural one (about 100 V/m) caused larvae to move toward lower field level zones in a rectangular tray exposed to the field. At lower field strengths, no significant change in the distribution of larvae was noted. Similar results were observed when a magnetic field was applied. In experiments where pupae were irradiated with 9.55 GHz microwave radiation (10 mW) for 2 hr, a 43% incidence in abnormally developed individuals after pupation was observed compared with a 10% incidence in abnormalities among nonirradiated controls.

5600 COMPATABILITY OF WEAK MAGNETIC ELF
FIELDS. (Eng.) Ludwig, H. W. (D-7400
Tuebingen, W. Germany). In: *Proceedings of Second
Electromagnetic Compatibility Symposium and Exhibition*. Sponsored by EUREL, URSI, EMC Gp, Int., AE-4 held in Montreux, Switzerland on June 28-30, 1977: pp. 483-484; 1977. (5 refs)

Experiments dealing with the exposure of humans to weak magnetic fields are reported. In double blind studies on 10 persons exposed to triangular-shaped alternating magnetic waves over a frequency range of 1-20 Hz and at a peak to peak field strength of 30 nanotesla or more, significant ($p<0.001$) changes in skin resistance (between the left and right hand) were observed. Different persons reacted differently to distinct frequencies, and the person's response was dependent on his vegetative status. Apart from changes in skin resistance, frequencies between about 1 and 6 Hz had a calming effect on subjects; whereas, frequencies between about 7 and 20 Hz had an excitable effect (tachycardia and nausea in extreme cases). An analgesic effect was seen at a frequency of 10 Hz. In a double blind study of 700 persons with ailments such as insomnia, nervousness, headaches, rheumatic pains, and circulation problems, exposure to extremely low frequency magnetic fields had a positive effect on 70-95% of the patients; subjects exposed to a sham magnetic field (controls) had only a 20% incidence of positive reactions.

5601 ENVIRONMENTAL IMPACT OF 60-HZ ELECTRIC
FIELDS ON THE GROWTH AND DEVELOPMENT OF
PLANTS. (Eng.) McKee, G. W. (Pennsylvania State
Univ., University Park, PA); Knievel, D. P.; Poz-
naniak, D. T.; Bankske, J. W. In: *Proceedings of
Second Electromagnetic Compatibility Symposium and
Exhibition*. Sponsored by EUREL, URSI, EMC Gp, Int.,
AE-4 held in Montreux, Switzerland on June 28-30,
1977: pp. 485-490; 1977. (7 refs)

Green plants of 79 species were exposed in environmentally controlled chambers to 60-Hz high intensity electric fields for periods up to 4 wk as part of a study to determine the environmental impact of extremely-high and ultra-high voltage power transmission lines. Extended exposure in fields up to 50 kV/m resulted in no damage to plants with rounded or blunt parts. However, terminal aerial plant parts with pointed or sharp tips or edges were often damaged by fields of 25-35 kV/m, with the apparent damage threshold for most species 20-25 kV/m. The tissue damage resembled that observed when plants transpire water more rapidly than can be absorbed by the roots and transported to the uppermost transpiring tissue. Damage during exposure to fields of 50 kV/m or less was typified by limited injury to only a small number of leaves or needles, and the area of the affected leaf tissue was typically less than 1% of the total leaf surface. A visible electric coronal discharge was observed at the same field strength and for the same plant geometries that resulted in tissue injury and death. The damage thresholds found in these studies, except for some monocotyledonous plants, such as wheat, oats, or corn, are higher than the field strengths that exist under present or even proposed transmission lines.

5602 AN EMC STANDARD FOR MEDICAL ELECTRONIC DEVICES. (Eng.) Hoff, R. J. (McDonnell Douglas Astronautics Co., St. Louis, MO 63166). In: *Proceedings of Second Electromagnetic Compatibility Symposium and Exhibition*. Sponsored by EUREL, URSTI, EMC Gp, Int., AE-4, held in Montreux, Switzerland on June 28-30, 1977: pp. 495-498; 1977. (9 refs)

Radiated and conducted emission measurements were made in a sample of ten hospitals and two emergency vehicles as part of an effort to establish an electromagnetic compatibility (EMC) standard for medical electronic devices. Electrosurgical units that produced large signals at 70 kHz and 1-5 MHz were the most significant sources of broadband radiated and conducted emissions, and diathermy equipment that produced large peak signals at 27 MHz were the source of the highest narrowband emissions found in hospitals. Based on the data obtained in this survey, a review of the literature, EMC tests on medical devices, and established EMC test methods, an EMC standard for medical devices was developed. The standard establishes maximum levels of electromagnetic emissions for medical devices and establishes minimum levels of electromagnetic interference to which medical devices must not be susceptible. The standard also contains referee test methods, which will be employed by the HEW, to determine compliance with the standard's requirements. Illustrative of the standard's contents and the rationale behind its requirements is the minimum radiated electric field susceptibility signal level, which is based on measured narrowband interference signals and signal levels produced in hospitals by nearby intentional emitters. The EMC standard also contains minimum radiated magnetic field susceptibility signal levels, minimum conducted susceptibility signal levels, maximum radiated narrowband emission signal levels, and maximum conducted narrowband and broadband emission signal levels.

5603 RADIATION THERAPY AND MICROWAVE THERAPY (433.92 MHz) IN THE TREATMENT OF ADVANCED CANCER (MEETING ABSTRACT). (Eng.) Hornback, N. B.; Shupe, R. E.; Shidnia; H.; Joe, B. T.; Sayoc, E.; Marshall C. In: *Abstracts of the 63rd Scientific Assembly and Annual Meeting of The Radiological Society of North America, Inc.* Sponsored by The Radiological Society of North America and the American Association of Physicists in Medicine. pp. 227; 1977. (0 refs)

The results of combined radiation and microwave (433.92 MHz) therapy for the treatment of over 100 patients with advanced cancer are presented, and the literature is briefly reviewed. Treatment afforded early, prompt relief of symptoms and may have long-term benefits.

5604 ELECTRICAL STIMULATION OF FRACTURE HEALING (MEETING ABSTRACT). (Eng.) Aho, A. J. (Turku Univ. Central Hosp., Turku, Finland); Aro, H.; Efkors, T. *Acta Orthop Scand* 48(5): 549; 1977. (0 refs)

The effect of asymmetrical alternating current on bone healing in the rabbit antebrachium was investigated. A transistorized multivibrator delivered asymmetrical alternating current that had positive and negative peaks (+22 μ A and -18 μ A in the radius group, +100 μ A and -100 μ A in the ulna group) and a small unidirectional current (+2 μ A in both groups). The frequency was 0.8 Hz, pulse duration 8 msec, and voltage limit 1 V; the voltage simulated a physiologic pattern of stress-generated electrical potentials in bone. In the radius group the current was led into the osteotomized bone with teflon-insulated platinum-iridium leads. In the ulna group the osteotomy site was externally transfixated with two Kirschner wires, which were used as electrodes. In the two stimulated groups histologic studies revealed an activated osteogenesis near the electrodes, particularly in the periosteum, which was more pronounced than the reaction at the fracture site. Both electrodes induced osteogenesis. In the control groups the osteogenic reaction around the electrodes was either minimal or nonexistent.

5605 THE USE OF EITHER REGIONAL OR WHOLE-BODY HYPEROTHERMIA AS AN ADJUNCTIVE TREATMENT WITH RADIOTHERAPY (MEETING ABSTRACT). (Eng.) Johnson, R. J. R. (Roswell Park Memorial Inst., Buffalo, NY 14240); Hetzel, F.; Sandhu, T. S.; Kowal, H. S. *Am J Roentgenol* 130(1): 191; 1978. (0 refs)

Studies were performed on patients with multiple superficial tumors to determine the thermal enhancement ratio of both tumor and normal skin following hyperthermia applied for 2 hr to both skin and tumor at a temperature of 41.5-42 C. The thermal enhancement ratio for the skin was calculated from skin scoring and tumor thermal enhancement ratio from regrowth data. Initial results from 30 cases suggested that post-radiation heating significantly improved the therapeutic

ratio for some tumors. Further cooperative studies using different histologic tumor types will be required to determine fully the feasibility of using whole-body hyperthermia and radiation.

- 5606 INFLUENCE OF DIFFERENTIAL HYPOTHERMIA ON THE DISTRIBUTION OF EXOGENOUS PEROXIDASE IN MICE WITH HEATED GLIOMAS (MEETING ABSTRACT). (Eng.) Sutton, C. H. (Dept. Neurological Surgery, Univ. Miami Sch. Medicine, Miami, FL 33152); Carroll, F. B.; Barrett, R. E. *Cryobiology* 14(6): 685; 1977. (0 refs)

The use of a tumor-body temperature differential to produce prolonged blood levels and enhanced accumulation of two antineoplastic agents by heated tumors in hypothermic mice was reported previously. To determine whether the distribution of substances with larger molecular weights is affected similarly by this temperature gradient combining moderate tumor hyperthermia (40-42°C) with body core hypothermia (28°C), a well-characterized tracer protein was employed. Horseradish peroxidase, an enzymatic basic protein, was injected at 2.5 mg/10 g in C57BL/6 mice bearing bilateral subcutaneous flank implants of a malignant glioma, the Zimmerman ependymoblastoma. One tumor in each animal was heated, while the contralateral implant assumed body temperature. An infrared lamp was used to heat tumors to a 40°C surface temperature in one series of mice. In another, tumors were heated with a microwave diathermy generator at 2,450 MHz. The use of microwave radiation produced more uniform tumor heating. The infrared lamp produced the highest temperature at the surface of the skin overlying the implant, with a rapid decrease in tumor temperature near the body wall. Animals were sacrificed after varying lengths of time, and plasma, tumors, and parenchymatous organs were homogenized and assayed for peroxidase activity with a fluorometric method. In the presence of body core hypothermia, the plasma clearance of peroxidase was retarded, and its uptake by liver and spleen was reduced. The addition of local hyperthermia increased the uptake of peroxidase by heated tumors, even in normothermic mice, but maximal accumulation resulted when tumor hyperthermia was combined with body core hypothermia.

- 5607 THERMOGRAPHIC STUDIES OF PHANTOM AND CANINE KIDNEYS THAWED BY MICROWAVE HEATING (MEETING ABSTRACT). (Eng.) Kilkowski, S. M. (Univ. Minnesota, St. Paul, MN 55108); Graham, E. F.; Lillehei, R. C. *Cryobiology* 14(6): 688; 1977. (0 refs)

Phantom kidneys composed of gelatin, KCl, and polyethylene glycol dissolved in distilled water and allowed to set in a kidney-shaped mold were frozen, packed in styrofoam containers, and placed in a microwave chamber for rewarming. The chamber was irradiated by long pulse (on time, 0.24 sec; off time, 0.22 sec) 2,450-MHz radiation repeated four times. The kidney halves were separated immediately, and thermograms were taken of the surface heat distribution. Kidneys from five dogs were selected on the basis of size compatibility with the phantom models

and perfused with cryoprecipitated plasma with 12.5% of one of the following cryoprotectants: dimethyl sulfoxide, glycerol, or ethylene glycol. Five kidneys were treated as the phantom models, and five were packed in the gelatin material. Again thermograms were taken of the surface heat distribution. Kidney-shaped phantoms showed intense hot spots due to the focusing effect of the parabolic interior surface of the kidney. The effect of changing conductivity of the models on the intensity of the hot spots produced was also demonstrated. Canine kidneys packed in styrofoam also showed hot spots. However, all gelatin packed kidneys except the one with ethylene glycol in the plasma showed uniform thawing above freezing but below body temperature.

- 5608 INFLUENCING FACTORS AND RESULTS OF ELECTROMAGNETIC THAWING OF RENAL TISSUE (MEETING ABSTRACT). (Eng.) Burdette, E. C. (Engineering Experiment Station, Georgia Inst. Technology, Atlanta, GA 30332); Karow, A. M., Jr., Cain, F. L. *Cryobiology* 14(6): 693; 1977. (0 refs)

The influence of the interaction of biomaterial, radiation frequency, and the electrical properties of the biomaterial was investigated during electromagnetic (EM) thawing of renal tissue. Kidneys from rabbits and dogs were perfused with one of several dimethylsulfoxide (DMSO) concentrations in a K^+ - Mg^{2+} rich perfusate, frozen, and thawed electromagnetically. The electrical properties of kidneys, which were measured both before and after EM thawing, were generally up to an order of magnitude greater in the thawed state than in the frozen state. The thawed kidneys were evaluated by simple anatomic (macroscopic and microscopic) and physiologic observations rather than by transplantation. Rabbit kidneys, which are no thicker than 2 cm, could be optimally (uniformly and rapidly) thawed by EM illumination at 2,450 MHz. Optimal thawing of canine kidneys, which are twice as thick as rabbit kidneys, required the insertion of electrode seeds into the renal pelvis prior to freezing; dual illuminations at 7 and 2,450 MHz were used. Increased DMSO concentrations in renal tissue illuminated with 2,450-MHz energy increased the electrical conductivity of the renal tissue for both the frozen and thawed states. Thus, DMSO decreased the EM thawing time and yielded kidneys with improved post-thaw morphology.

- 5609 CANINE RENAL CRYOPRESERVATION USING DIMETHYL SULPHOXIDE, HELIUM PERfusion, AND MICROWAVE THAWING (MEETING ABSTRACT). (Eng.) Pegg, D. E. (Div. Cryobiology, Clinical Res. Centre, Watford Rd., Harrow, HA1 3UJ, England); Green, C. J.; Walter, C. A. *Cryobiology* 14(6): 695; 1977. (1 ref)

An attempt was made to confirm the findings of an earlier study in which canine kidneys were perfused with a solution containing dimethyl sulphoxide (DMSO) followed by helium gas and were then cooled to -80°C, held at that temperature for 15 min, thawed by microwave irradiation at 2,450 MHz, and transplanted. Nine dogs, of a total of 17 tech-

nically satisfactory experiments, survived on a single frozen kidney. In the present study the perfusion of 1.4 M DMSO in Sacks' solution was associated with a progressive increase in vascular resistance even when a Leucopac filter was included in the circuit. The flow rate of helium gas during cooling was only 10-12% of that reported previously, but cooling was efficient, and a stable core temperature of -80°C was obtained for 15 min. Microwave thawing without burning could not be obtained by the published technique, but it was possible by using six 8-sec bursts of irradiation with 10-sec pauses to obtain complete thawing without evidence of dangerous increase in temperature of any part of the organ. Some kidneys were then perfused for 1 hr and subjected to light and electron microscopic examination. Although the light microscopic appearances were excellent, the ultrastructure was severely disturbed. Other kidneys were transplanted, but none has been capable of supporting life.

5610 RESTORATION OF PHAGOCYTOSIS AFTER FREEZING AND MICROWAVE THAWING OF GRANULOCYTES (MEETING ABSTRACT). (Eng.) Popovic, V. (Dept. Physiology, Emory Univ. Sch. Medicine, Atlanta, GA 30322); Schaffer, R.; Popovic, P.; Burdette, E. C. *Cryobiology* 14(6): 698; 1977. (0 refs)

Restoration of phagocytosis was studied after freezing and microwave thawing of granulocytes obtained from rat white blood cells (WBC) that were collected, separated, and concentrated using a 2% (volume/volume) gelatin. After pretreatment with a single vinblastine injection and daily Deca-Durabolin for 10 days, the yield of granulocytes from donor rats was increased 12 times. Gelatin supernatant, containing WBC from several rats was pooled and expressed into 20 ml of freezing bags to which 1.2 ml of dimethyl sulfoxide was slowly added. The WBC were frozen (2°C/min) to a temperature of -50°C and kept at this temperature for 2 or 24 hr. During each freezing experiment, two control bags with WBC were kept at room temperature. The WBC were thawed with a microwave system (2,450 MHz) at a rate of 60°C/min to a temperature of 25°C. Two-ml aliquots of suspended WBC were taken from each bag before freezing, after thawing, after serial dilution, and after centrifugation (the supernatant aspirated to the original volume) and incubated with yeast for 2 hr. Fifty-four to 62% of gelatin frozen-microwave thawed granulocytes preserved fully their phagocytic property. When dextran was used for separation, only 0-3% of granulocytes showed weak phagocytosis after freezing and surface or microwave thawing.

5611 PROCEDURES FOR SUCCESSFUL 24-HR-LONG FREEZING AND MICROWAVE THAWING OF GRANULOCYTES (MEETING ABSTRACTS). (Eng.) Popovic, V. (Dept. Physiology, Emory Univ. Sch. Medicine, Atlanta, GA 30322); Popovic, P.; Burdette, E. C.; Schaffer, R. *Cryobiology* 14(6): 698-699; 1977. (0 refs)

A method for the microwave thawing of frozen granulocytes is presented. Donor rats were pretreated once

with vinblastine and for 10 days with Deca-Durabolin to obtain increased yield (12x the normal value) of granulocytes. During puncture of abdominal aorta and collection of blood, the donor rats were made hypervolemic (50% of calculated blood volume) by injection of 3% of heparinized gelatin solution to avoid sudden decrease of arterial blood pressure and adherence of circulating granulocytes to walls of blood vessels. The collected blood was mixed with 30% more volume of 3% gelatin to obtain about 2% gelatin solution that sedimented white blood cells (WBC) from the rest of the blood in about 20 min. The bags with WBC (5.6 x 14.7 x 1.5 cm) were frozen between metal plates at 2°C/min to a temperature of -50°C by placing the frames with bags into a mechanical freezer. To provide a uniform internal field distribution and to efficiently transfer energy to the frozen cells, a microwave system was used. A frequency of 2,450 MHz was chosen because the depth of electromagnetic-field penetration at this frequency was well suited to the thickness of the blood freezing bags (1.3 cm). A flared wave-guide horn radiator (6.4 x 15.2 cm) mounted vertically and packed with titanium dioxide (TiO_2) and silicon dioxide (SiO_2) was used as dielectric frozen granulocytes and the electromagnetic source. After washing, centrifugation, and volume restoration, 54-62% frozen-thawed granulocytes were able to phagocytize.

5612 DISTRIBUTION OF EXOGENOUS PEROXIDASE IN NORMOTHERMIC AND HYPOTHERMIC MICE WITH HEATED GLIOMAS (MEETING ABSTRACT). (Eng.) Sutton, C. H. (Univ. Miami Sch. Medicine, Miami, FL 33152); Carroll, F. B.; Barrett, R. E. *Fed Proc* 37(3): 431; 1978. (0 refs)

A tumor-body temperature differential used to produce prolonged blood levels and enhanced accumulation of two anti-neoplastic agents by heated tumors in hypothermic mice was reported previously. To determine if the distribution of substances with larger molecular weights is affected similarly by combining moderate tumor hyperthermia (40°C-42°C) with body core hypothermia (28°C), horseradish peroxidase was injected (2.5 mg/10 g body weight) in C57BL/6 mice bearing bilateral subcutaneous flank implants of the Zimmerman ependymoblastoma. One tumor in each animal was heated, while the contralateral implant assumed body temperature. Two methods of heating tumors were compared. An infrared lamp was used to heat tumors to a 40°C surface temperature in one series of mice. In another, tumors were heated with a microwave diathermy generator at 2,450 MHz. The use of microwave radiation produced more uniform tumor heating. In the presence of body hypothermia, plasma clearance of peroxidase was retarded and its uptake by liver and spleen was reduced. The addition of local hyperthermia increased the uptake of peroxidase by heated tumors, even in normothermic mice, but maximal accumulation resulted when tumor hyperthermia was combined with body core hypothermia.

- 5613 PLASMA CORTICOSTERONE TRENDS IN RESPONSE TO ELECTRIC FIELDS (MEETING ABSTRACT). (Eng.) Hackman, R. M. (Pennsylvania State Univ., University Park, PA 16802); Graves, H. B. *Fed Proc* 37(1): 831; 1978. (0 refs)

Plasma corticosterone concentration was determined by radioimmunoassay for mice exposed to 60-Hz electric fields of 0 dB/s, 25 dB/s, or 50 dB/s for 5-min to 6-wk periods. Responses of mice exposed to stressors, such as, moving, socially mixing, and noise stress were also assessed. An acute, transient increase in circulating corticosterone was apparent 5 min after activation of a high intensity electric field and during periods when the field was rapidly switched on and off. The increase lasted only a few min, and corticosterone concentration was normal after exposure of several hr, days, or wk. In contrast, mice that were moved, socially mixed, and exposed to noise levels of 100 dB had corticosterone levels that were consistently two or three times greater than undisturbed mice or mice exposed to high intensity, 60-Hz electric fields. It is concluded that mice can perceive high intensity 60-Hz electric fields but exhibit only orientation reactions to the onset or offset of such fields.

- 5614 OBSERVATIONS ON MOUSE FETUSES EXPOSED TO 2.45 GHZ MICROWAVE RADIATION (MEETING ABSTRACT). (Eng.) Berman, A. (Environmental Res. Center, Research Triangle Park, NC 27711); Carter, H. B. *Health Phys* 33(6): 661; 1978. (0 refs)

Pregnant mice were exposed to 2.45 GHz radiation for 100 min daily during organogenesis and fetal stages at a range of power densities (3.4 to 28 mW/cm²). The fetuses were examined for gross external morphologic and other alterations near-term. Fetal weight was decreased significantly at the highest power density, especially in litters that contained dead fetuses. There was a high incidence of litters with exencephaly possibly related to power density. An exposure of 13.6 mW/cm² for 100 min was not thermally significant. The results of application of twin-well calorimetric techniques to multi-animal exposure to determine specific absorption rates will be discussed.

- 5615 NONIONIZING RADIATION LEVELS AND POPULATION EXPOSURE IN URBAN AREAS OF THE EASTERN UNITED STATES (MEETING ABSTRACT). (Eng.) Athey, T. W. (EPA, 9100 Brookville Rd., Silver Spring, MD 20910); Tell, R. A.; Hankin, N. N.; Janes, D. E. *Health Phys* 33(6): 661; 1978. (0 refs)

The EPA program for determining the need for environmental radio frequency exposure standards is briefly described, and one method of predicting population exposure is presented. Environmental data were collected with a van mounted system consisting of antennas, a spectrum analyzer, and a minicomputer. Measurements were made in seven frequency bands between 0.01 and 900 MHz in which pilot studies had indicated that the most significant environmental exposures occur. Environmental data were collected

at 193 sites in seven cities in the eastern United States. Values of power density integrated over the frequency range from 55 to 900 MHz generally fall into the range between 0.001 and 1.0 μ W/cm² with a median site value of about 0.02-0.03 μ W/cm². A model was developed to extrapolate the measured data to other points within the seven cities. By combining this model with an automated population data base, estimates of population exposure were obtained.

- 5616 SOME EFFECTS OF 3300 MHZ MICROWAVES OF OXYGEN UPTAKE IN GERMINATING PEAS (MEETING ABSTRACT). (Eng.) Brumfield, R. (Botany Dept., Univ. Wisconsin-Madison, Madison, WI 53201); Earley, A. L. *Health Phys* 33(6): 662; 1978. (0 refs)

Germinating peas, soaked in water for 28-29 hr, were subjected to microwave irradiation. The oxygen uptake was measured before, during, and after exposure. The temperature of the internal pea tissue and the surrounding air was determined for a 10-min irradiation. The internal pea temperature increased 1.2 C, and the air temperature in the irradiation vial increased 0.25 C during the irradiation. There was a slight decrease in oxygen uptake when the peas were exposed to 1 mW/cm²; at 5 mW/cm² the decrease was greater than 50%. When the peas were soaked in a 2.5 glucose solution for 18-20 hr, the decrease in oxygen uptake at 5 mW/cm² was about 9%. When the peas were soaked in glucose-¹⁴C, ¹⁴CO₂ showed that the external glucose was utilized. Embryo axes and cotyledons excised from peas germinating for 18-20 hr were subjected to 5 mW/cm² microwave irradiation. There was a small decrease in the oxygen uptake for the embryo axes and a larger decrease for the cotyledons, indicating that the effect was primarily in the cotyledon. The data indicated that the effect was in the metabolic pathway from starch to glucose.

- 5617 LOW INTENSITY MICROWAVE EFFECTS ON THE SYNTHESIS OF THYROID HORMONES AND SERUM PROTEINS (MEETING ABSTRACT). (Eng.) Travers, W. D. (U.S. Nuclear Regulatory Commission, Washington, DC 20555); Vetter, R. J. *Health Phys* 33(6): 662; 1978. (0 refs)

The effects of chronic, low intensity microwave irradiation on the thyro-binding capacity and levels of triiodothyronine, thyroxine, thyroid stimulating hormone, albumin proteins, and alpha-, beta-, and gamma-globulin proteins in rat serum were investigated. Animals were exposed to 0, 4, or 8 mW/cm² (2,450 MHz) 8 hr/day for 0, 7, 14, or 21 days. Four animals exposed for 21 days at each level received sham exposures from days 22 to 28 to test for recovery from effects. Following treatment, animals were sacrificed, and serum samples were analyzed via radioimmunoassay, competitive binding technique, or electrophoresis. Power density and exposure time showed significant ($p<0.05$) effects. A power density of 8 mW/cm² induced significant decreases in the serum levels

of thyroxine, thyroid-stimulating hormone, and albumin proteins and significant increases in alpha-globulin proteins and serum thyro-binding capacity. A high correlation between decreases in thyroxine and thyroid-stimulating hormone suggest that the depressed thyroid activity is directly related to decreased serum levels of thyroid-stimulating hormone. The lowered thyroid hormone levels in serum probably contributed to a change in normal protein metabolism, which resulted in alterations in serum protein fraction. The results suggested that thermal energy deposited by chronic, low intensity microwave exposure interacted directly or indirectly with the hypothalamus to cause thyroid suppression and serum protein alteration.

- 5618 A NONINVASIVE MICROWAVE APNEA DETECTOR (MEETING ABSTRACT). (Eng.) Lin, J. C. (Dept. Electrical and Computer Engineering, Wayne State Univ., Detroit, MI 48202); Dawe, E.; Majcher-ek, J. *IEEE Trans Biomed Eng* 25(1): 115; 1978. (0 refs)

A microwave device capable of registering instantaneous respiratory changes in infants is described. The source is a 100 mW 13.8 GHz microwave circuit module (MMIC). Bipolar transistors that oscillate transmitting and receiving functions. The operating frequency is 13.8 GHz, and the maximum power density at a distance of 30 cm is less than 0.01 mW/cm². In preliminary tests, both the audio and visible alarms were triggered whenever an apnea lasted 30 sec or longer. The advantages of the device include non-contact application, which eliminates such problems as loose electrode connections, skin irritation, and restriction of breathing. In addition, movement introduced in the immediate vicinity of the incubator does not interfere with the operation of the detector.

- 5619 SENSATIONS PRODUCED BY ELECTRICAL TOOTH-PULP STIMULATION (MEETING ABSTRACT). (Eng.) McGrath, P. A. (Neurobiology and Anesthesiology Branch, Natl. Inst. Dental Res., Bethesda, MD); Gracely, R. H.; Heft, M. W.; Dubner, R. *J Dent Res* 57(Special Issue A): 65; 1978. (0 refs)

Detection thresholds for nonpain sensations and pain thresholds were determined as a function of the frequency of an applied electric stimulus. Electrical stimuli were 1-sec trains of monopolar, monophasic, cathodal, 1-msec duration, constant current pulses delivered to the labial surface and incisal edge of upper incisor teeth. Using the methods of limits and constant stimuli, five subjects reported detection thresholds that were significantly lower than pain thresholds at all frequencies studied (5, 10, 25, 50, 100, 250, and 500 Hz). Mean detection thresholds remained constant at 8 μ A; mean pain thresholds varied nonmonotonically with frequency, decreasing from 26 μ A at 5 Hz to 20 μ A at 100 Hz, and increasing to 25 μ A at 500 Hz. Subjects scaled the intensity of toothpulp sensations between detection and pain thresholds by choosing words from a randomized list of sensory

verbal descriptors (e.g., mild, moderate, strong) or by using a metric scale. The scales show that sensation is monotonically related to stimulus intensity independent of frequency and that current and frequency interact, such that sensation increases as frequency increases at a rate proportional to stimulus intensity. The experiments showed that (1) detectable toothpulp stimuli do not necessarily produce pain even at frequencies up to 500 Hz; (2) subjects are able to scale nonpain and pain sensations produced by toothpulp stimulation; and (3) temporal summation occurs in proportion to stimulus intensity.

- 5620 REACTION OF PRIMARY TEETH TO ELECTRIC CURRENT (MEETING ABSTRACT). (Eng.) O'Toole, T. (Univ. Louisville, Louisville, KY). *J Dent Res* 57(Special Issue A): 226; 1978. (0 refs)

The response of normal, healthy primary teeth to electrical stimulation was studied. The anterior teeth of 22 children, 4-7 yr age, were electrically stimulated. Each subject was examined under controlled conditions on three successive weekly visits. The electrical stimulation was provided by a modified S.S. White 2A microammeter with a 0-30 microammeter dial along with the original 0-100 dial. The mean of all the teeth were between 2 and 8 μ amp, 97.1% were between 2 and 12 μ amp, and 99.7% were \leq 20 μ amp. Significant differences were shown between centrals, laterals, and canines (F value=3.96), individual patients (18.0%), and upper and lower arches (22.0%). No significant difference was shown between the sexes in the original sample, but when replication was used to reduce the residual error, a strong significant difference was observed (10.2%). No significant differences were shown between the following individual groups: age, visits, and right and left sides of the arch. This study demonstrated that males had a higher range of readings than females, and upper teeth had a higher range than lower teeth. The canines had lower readings than the centrals in the same arch.

- 5621 PHYSICAL AND METABOLIC CHANGES IN HUMAN TISSUE CELLS PERTURBED BY AN ELECTRIC FIELD (MEETING ABSTRACT). (Eng.) Norton, L. A. (Univ. Connecticut Sch. Dental Medicine, Farmington, CT); Bourret, L. A.; Majeska, R. J.; Rodan, G. A. *J Dent Res* 57(Special Issue A): 301; 1978. (0 refs)

The effects of electric fields (EF) on normal bone cells and on malignant cells (which differ in their surface properties) were compared, and the effects of EF on cell attachment were examined. Osteocytes (OST) and osteogenic sarcoma (ROS) tissue cultures were prepared from 20-day rat embryo calvaria and rat osteogenic sarcoma, respectively. They were maintained horizontally in a roller drum in MCDB medium, 10% fetal calf serum, 1% antibiotics at 37°C with 5% CO₂. Culture tubes containing OST or ROS were incubated in MCDB for 6 hr at 37°C with or without electrical perturbation produced by a square wave, unipolar

EF of 1,166 V/cm oscillating at 5 Hz. The cells were removed from the culture tubes by trypsin digestion at 37°C for 15 min. This procedure released significantly fewer cells from the cultures exposed to EF. In bone cells 819±82 were released from the EF samples versus 1,214±38 from the respective controls ($p<.01$). In R05 cells the findings were 1,875±117 for the EF samples and 2,491±194 for the control samples. The reduction in the ability of trypsin to remove the cells from the culture tube wall after EF exposure indicated an increase in the adhesive properties of the cell. This may reflect a change in cell membranes possibly related to the previously reported effects on DNA replication.

5622 EFFECT OF MINUTE ELECTRIC CURRENTS ON CYCLIC NUCLEOTIDES OF CAT PERIODONTAL TISSUES (MEETING ABSTRACT). (Eng.) Davidovitch, Z. (Sch. Dental Medicine, Univ. Pennsylvania, Philadelphia, PA); Korostoff, E.; Shafrazi, J.; Montgomery, P.; Finkelman, R. *J Dent Res* 57 (Special Issue A): 348; 1978. (0 refs)

The effect of minute local electric currents on cat periodontal and alveolar bone cyclic nucleotides was studied. Three groups, two cats each, were treated electrically for 1, 3 and 7 days. The current (constant direct current, 15±2 vamps) was provided by a power-pack encased in a palatal acrylic plate. The cathode was placed mesial to one maxillary canine, while the anode was positioned distally. Fresh frozen 6- μ horizontal sections of whole maxillae were stained for cyclic adenosine monophosphate (cAMP) and cyclic guanosine monophosphate (cGMP). At all time stages, the intensity of cAMP staining of gingival and periodontal fibroblasts and periodontal osteoblasts near the cathode intensified markedly. A wide osteoid layer was observed near the cathode at day 7. Intense staining for cGMP was seen mainly in the osteoprogenitor cell group. Staining for both cyclic nucleotides was very intense in periosteal cells adjacent to the anode, where resorptive activity was occurring at day 7. The results demonstrated the ability of minute electric currents to evoke bone remodeling processes in limited areas of alveolar bone and indicated that cAMP and cGMP may serve as second messengers in these cellular responses.

5623 SCATTERED MICROWAVE FIELDS NEAR A FINITE, PLANAR, DIELECTRIC SLAB (MEETING ABSTRACT). (Eng.) Tricoles, G. (General Dynamics Electronics Div., P. O. Box 81127, San Diego, CA 92138); Rose, E. L.; Hayward, R. A. *J Optical Soc Am* 67(10): 1394; 1977. (2 refs)

The fields produced by plane waves incident on dielectric slabs of finite length and thickness were determined numerically and experimentally. The numeric results were produced by applying a moment method, and the experimental data were measured with a small antenna in a microwave interferometer. The field was determined at locations just outside the slabs and at distances up to several wavelengths

for incidence ranging from normal to grazing. Slab thicknesses were a quarter wavelength or less. For non-normal incidence at 45° and 90°, intensity fringes were present in the measured and computed data. These fringes were produced by interference of slab-guided waves and free-space waves. Fringe spacings agreed well with values predicted by a simple model that utilized the propagation constant of guided waves on infinitely long slabs. The moment method determined the magnitude and phase of the guided waves and the effects of guided waves reflected at the ends of the slabs.

5624 TREATMENT OF CANINE OSTEOSARCOMA USING ALLOGRAFTS, ADJUVANT CHEMOTHERAPY AND/OR HYPEROTHERMIA OF METASTATIC SITES (MEETING ABSTRACT). (Eng.) Theilen, G. H. (Sch. Veterinary Medicine, Univ. California, Davis, CA 95616); Kagan, K.; Leighton, R. L.; Madewell, B.; Snow, H.; Stann, S. *Proc Am Assoc Cancer Res* 19: 1224; 1978. (0 refs)

The results of treatment of canine osteosarcoma combining allografts, adjuvant chemotherapy, and/or hyperthermia are presented. Six dogs treated with resection and adjuvant chemotherapy had a mean survival of 8 mo, and 14 treated with adriamycin (60) alone had a mean survival of 104 days. Two dogs treated by resection and adjuvant A, imidole carbostecide, vincristine, and Cytosan had a mean survival of 8 mo, and three treated with allografts had a mean survival of 11 mo, and two are alive, disease-free 13 and 18 mo later, respectively. Feasibility studies using radio frequency hyperthermia to metastatic foci (combined with resection for preservation of the limb) resulted in complete resolution of lung disease in one dog; the dog was alive and disease free 7 mo later.

5625 MICROWAVE COOKING ISN'T SO SIMPLE. (Eng.) Gerling, E. E. (Gerling Moore, Inc., subsidiary of Chemetron Corp., Palo Alto, CA). *Food Eng* 50(2): 96-98; 1978. (0 refs)

Actual power output from seven commercial microwave ovens made by five different manufacturers (three American and two Japanese) was measured using the NBS Test Procedure for Conventional Ranges, Ovens and Cooking Tops and various test procedures recommended by the manufacturers. The NBS procedure involved a calorimetric computation measuring the power delivered to four different water loads (275, 500, 1,000, and 2,000 g). The water, initially at a temperature of about 20°C, contained 1% by weight of salt and was heated until the temperature rose approximately 25°C. The ovens were operated at the line voltage rated for the oven by the manufacturer. For rated power outputs of 675, 500, 600, 500, 650, 600, and 550 W for the seven ovens tested, the actual power measured with the NBS procedure was 577, 409, 456, 425, 563, and 493 W, respectively. The NBS test without salt gave an average power output of 61 higher than the test with salt. Using various tests recommended by the manufacturers, differences in power output with respect to the NBS test as high as 20% were

observed. In addition to the above discrepancies, oven regulation (difference in power measured at 120 V and at 110 V divided by the power at 115 V) also varied from oven to oven; the variation ranged from as low as 3.5% to as high as 20.0%. It is concluded that standardization of the test procedure for power output is needed and that it is not easy to find a way to improve on the test procedure for power output proposed by the NBS.

- 5626 LONG-TERM EFFECTS OF 2.45-GHZ RADIATION ON THE ULTRASTRUCTURE OF THE CEREBRAL CORTEX AND ON HEMATOLOGIC PROFILES OF RATS. (Eng.) Switzer, W. G. (Dept. Bioengineering, Southwest Res. Inst., 8500 Culebra Road, San Antonio, TX 78284); Mitchell, D. S. *Radio Sci.* 12(65): 287-293; 1977. (26 refs)

A multimode microwave exposure chamber was used to investigate potential long-term changes in the ultrastructure of the cerebral cortex of rats that were chronically exposed to low intensity continuous wave microwave radiation. To maximize the opportunity to observe long-term structural changes, a final recovery period was interposed between the test of 110 daily microwave exposure sessions and the preparation of tissue samples for subsequent electron microscopic examination. Relative to sham-irradiated control subjects, exposure to 2.45-GHz radiation at an averaged specific absorption rate of 2.3 mW/g produced a statistically significant increase in the occurrence of myelin figures in cortical dendrites of irradiated animals. No other remarkable structural changes were observed. Hematologic analyses revealed a significant elevation in the red blood cell count from a control value of 7.77×10^6 to a postirradiation value of 8.46×10^6 . Differential white blood cell counts produced evidence of several marginally significant irregularities. Periodic samples of rectal temperature obtained during the course of irradiation revealed no indication of whole-body heating. The results of this study and other related investigations indicate that exposure to low intensity microwave irradiation can result in both transient and in long term structural anomalies in the central nervous system tissue and may result in various hematologic irregularities. However, the functional significance of such effects remains uncertain.

- 5627 AN ANALYSIS OF RADAR EXPOSURE IN THE SAN FRANCISCO AREA. (Eng.) Tell, R. A. (Environmental Protection Agency, Office of Radiation Programs, P.O. Box 15027, Las Vegas, NV 89114). 18 pp; 1977. [Environmental Protection Agency Technical Note ORP-EAD 77-3]. (3 refs)

An analysis of radar exposure data for the San Francisco area that was obtained during the period June-August 1975 is presented. The data included measurements in the 1,030 radar beacon band (interrogators) and the 1,215-1,400-MHz, 2,700-3,700-MHz, 5,350-5,925-MHz, and 8,500-10,500-MHz radar bands. Radar exposure determined at a Palo Alto site was

$2.7 \times 10^{-4} \mu\text{W}/\text{cm}^2$ and at a Bernal Heights site $1.1 \times 10^{-3} \mu\text{W}/\text{cm}^2$ for the top 10 contributing sources at each location. Exposure in the 2,700-2,900-MHz band at a Mt. Diablo site was $2.6 \times 10^{-5} \mu\text{W}/\text{cm}^2$. These values are generally equal to or lower than commonly existing radio frequency fields from signals in the broadcast service on the basis of past EPA measurements. Based on these results it seems that radars are not a major perturbation of the ambient electromagnetic radiation exposure picture.

- 5628 ELECTRICAL MODIFICATION OF BLOOD FLOW (LETTER TO EDITOR). (Eng.) Cook, A. W. (Long Island Coll. Hosp., 340 Henry St., Brooklyn, NY 11201). *South Med J.* 71(2): 225; 1978. (2 refs)

The use of electrical stimulation of the spinal cord to treat patients with vascular disease of the extremities is reported. Regional vasodilation occurred in response to the electrical stimulation even in patients who had been unsuccessfully treated with sympathectomy and arterial bypass. In one patient with infarction of the dorsum of a foot, electrical stimulation of the spinal cord resulted in complete epithelialization in the affected zone within 8 wk; after 1.5 yr of continued spinal cord stimulation, subsequent recurrence or breakdown has not occurred. Spinal cord stimulation has also been used to significantly modify the pain associated with chronic ischemia.

- 5629 GENERAL ADAPTATION SYNDROME AND MAGNETOSTATIC FIELDS: EFFECTS ON SLEEP AND BEHAVIORAL REINFORCEMENT OF LOW RATE. (Eng.) Lafarge, R. (Dept. Psychologie and Sociologie, Universite Laval, Quebec, Canada); Molinari, R.; Champagne, F.; Anguille, R. *J. Psychol. N.Y.* 99-95; 1978. (31 refs)

Sleep and operating responses under delayed reinforcement of low rate (DLR) for rats exposed continuously to a vertical magnetostatic field of 3,000 G for a period of 30 days were observed. In a first series of experiments, variation in sleeping periods for each of four animals was observed, and an evolution characteristic of the different phases of the general adaptation syndrome was noted (reaction, counterreaction, and resistance). The same phenomenon was observed in operating responses under DLR at 5 and 10 sec, and each of the animals showed decreased weight growth. The effect of the magnetic field was comparable to that of other stressing agents. These behavioral observations illustrate the need for long exposure studies dealing with specific and nonspecific effects of magnetostatic fields.

- 5630 OPINIONS SIZZLE OVER RF HAZARDS (LETTER TO EDITOR). (Eng.) Osepchuk, J. M. (IEEE Committee on Man and Radiation, Waltham, MA 02154). *Microwaves* 17(1): 110; 1978. (1 ref)

In response to literature dealing with the assumption that there are hazardous nonthermal effects from low density nonionizing radiation, it is

stated that fear which feeds on the absence of verified or verifiable evidence is hampering basic studies and may thereby restrict medical development and the application of radiofrequency radiations.

5631 **BIOLOGICAL EFFECTS OF HIGH STRENGTH ELECTRIC FIELDS. SECOND INTERIM PROGRESS REPORT SEPTEMBER 1976 - MARCH 1977.** (Eng.) Phillips, R. D.; Kaune, W. T. (Battelle Pacific Northwest Lab., Richland, WA). 116 pp; 1977. [available through National Technical Information Services, Springfield, VA 22161, Document No. CONS/1830-2]. (8 refs)

Progress made on a project to determine the biological effects of high strength electric fields on small laboratory animals is reported. Topics discussed include the design, construction, and testing of a prototype and special studies exposure system; the design and construction of exposure systems for rats and mice; dosimetry; experiments to determine the maximum field strength that does not produce corona discharge, ozone formation, shocks to the animal, hair stimulation, or a behavioral preference by rats to avoid exposure to the field; and preparations for the biological screening experiments. The special studies exposure system is free of corona discharge at a field strength of 130 kV/m, and rats do not receive shocks in their cages at this field strength. At a field strength of much greater than 130 kV/m, visible hair movement was detected. Rats given the option of being exposed or not exposed to vertical 60-Hz electric fields exhibited a preference not to be exposed at field strengths of 90, 105, and 130 kV/m; whereas, at field strengths of 0, 50, 60, and 75 kV/m there was no statistically significant preference for or against exposure. Experiments conducted to determine the effect of exposing rats to 80 kV/m for 8 hr and 40 hr (8 hr/day for 5 days) using the special studies exposure system revealed that heart rates of exposed animals did not differ significantly from those of sham-exposed controls. Procedural and baseline measurements for biological screening experiments have been completed, and the first series of biological screening experiments was scheduled to start April 5, 1977.

5632 **MICROWAVE-INDUCED CHRONOTROPIC EFFECTS IN THE ISOLATED RAT HEART.** (Eng.) Olsen, R. G. (Naval Aerospace Medical Res. Lab., Biomedical Div., Pensacola, FL 32508); Lords, J. L.; Durney, C. H. *Ann Biomed Eng* 5(4): 395-409; 1977. (24 refs)

The effects of continuous wave 960-MHz microwave irradiation on isolated perfused rat hearts were studied using a modified Langendorff preparation. With the use of a liquid-crystal optical-fiber temperature probe, it was shown by calorimetric methods that bradycardia occurred at microwave dose rates of 1.3 and 2.1 mW/g; these dose rates should have caused mild tachycardia in the heart based on the thermogenic properties of the irradiation.

The observed bradycardia, moreover, exhibited neurologic features because atropinized hearts showed strong tachycardia during irradiation and hearts treated with propranolol showed significantly stronger bradycardia during irradiation than that seen without drugs. It is hypothesized that microwave energy interacts with the remaining portion of the autonomic nervous system within the heart to produce the observed chronotropic effects.

5633 **MICROWAVE ABSORPTION AND ITS BIOLOGICAL EFFECTS.** (Eng.) Webb, S. J. In: *Nutrition Time and Motion in Metabolism and Genetics*. (Springfield: Charles C. Thomas): 246-275; 1976. (refs)

Studies on microwave absorption in biological studies using various types of cells are reported. Growth of *Escherichia coli* was slowed or interfered with by microwaves at a frequency of 136 GHz, and frequencies of 66 and 73 GHz also slowed or stopped the syntheses of deoxyribonucleic acid and protein as well as the proliferation of cells. An analysis of these data revealed that frequencies able to affect metabolic processes of proliferating cells were separated by integral multiples of 7 GHz. It was also found that frequencies able to interfere with the growth of cells could be divided into two groups: one group strongly inhibited the proliferation of cells and the other did so weakly. Experiments with various types of tumor cells revealed that microwave irradiation resulted in a loss of tumorigenicity, with the tumor cells strongly absorbing microwaves at frequencies of 67, 69, 71.5, 73, and 75.5 GHz. This suggested a frequency series separated by approximately 2.5 GHz. The absorption of the above microwave frequencies seemed to represent transitions from one quantum value to another, of one rotational movement of water on one of its own axes, or, the movement of whole water molecules, termed motation. It is hypothesized that the attenuation of a series of microwave frequencies, able to affect metabolic processes, is due to the motation of water around the periphery of macromolecules.

5634 **MICROWAVE EXPOSURE ARRAY: IMPROVED FIELD MEASUREMENTS.** (Eng.) Oliva, S. A. (Armed Forces Radiobiology Res. Inst., Defense Nuclear Agency, Bethesda, MD 20014). 15 pp.; 1977. [available through National Technical Information Services, Springfield, VA 22161, Document No. AD A045142]. (3 refs)

Improved field measurements for Styrofoam and Plexiglas cages and a microwave exposure array previously designed and constructed at the Armed Forces Radiobiology Research Institute are described. A new miniature isotropic electric field probe designed by the Bureau of Radiological Health was used, and the measurements demonstrated the effectiveness of the cages for microwave research. The Styrofoam and Plexiglas cages were demonstrated to cause field perturbations ranging from 0-0.65 dB, depending on cage orientation and the location at

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which the probe was inserted in the cage. An analysis of field measurements of the complete microwave exposure array without rats and with rats in all cages indicated that the power density in the exposure array varied by as much as $\pm 23\%$ from the average power density in the cages farthest from the antenna due to scattering from moving rats in other cages; however, the average value in any cage varied by no more than $\pm 5\%$ from the composite average of all cages. The phase difference between cages was not considered as the size of the cages was greater than one wavelength (12.34 cm) in all dimensions. The animals, being free to move, would thus be exposed to the field in many different phases, depending on their location in the cage at the time. The array was located in the far field of the antenna, with the closest cage being 4.5 m from the antenna.

5635 EXTREMELY LOW FREQUENCY (ELF) VERTICAL ELECTRIC FIELD EXPOSURE OF RATS: IRRADIATION FACILITY. (Eng.) Mathewson, N. S.; Oliva, S. A.; Oosta, G. M.; Blasco, A. P. (Armed Forces Radiobiology Res. Inst., Defense Nuclear Agency, Bethesda, MD 20014). 55 pp; 1977. [available through National Technical Information Services, Springfield, VA 22161, Document No. AD A045080]. (12 refs)

An extremely low frequency (ELF) vertical electric field irradiation facility consisting of six identical exposure chambers is described. The facility simulates the vertical electric field radiated from the United States Navy's proposed ELF communications system, which is designed to establish worldwide communication with its submarine fleet. The irradiation facility is designed to study the possible bioeffects of ELF on 96 rats equally divided among the six exposure chambers and individually housed in specially modified nonmetallic cages. These cages are designed to minimally perturb the exposure field and provide accurate means to measure food and water consumption. Each exposure chamber can be independently operated up to field strengths of 1,000 V/m (root mean square) at any sinusoidal ELF frequency. At 45 Hz, the frequency chosen for this research, chamber cross-talk is less than -60 dB and the vertical electric field uniformity within the exposure area is $\pm 5\%$.

5636 THEORETICAL APPROACH TO THE EFFECTS OF EXTREMELY LOW FREQUENCY ELECTROMAGNETIC FIELDS ON PHYSARUM POLYCEPHALUM. (Eng.) Wayland, J. R. (Fuel Cycle Risk Analysis Div., Sandia Lab., Albuquerque, NM 87115). 20 pp.; 1977. [available through National Technical Information Service, Springfield, VA 22161, Document No. SAND 77-0211].

Absolute reaction rate theory is used to explain the increased time between successive synchronous mitotic divisions of the slime mold *Physarum polycephalum* (Pp) when exposed to extremely low frequency (45-75 Hz) electromagnetic fields of 2.0 G and 0.7 V/m. The delay is found to be caused by an alteration of a molecule that must reach a

critical concentration before mitotic activity begins. The precise molecule(s) is not identified. By ignoring the transition period from the normal (control) mitotic cycle to the lengthened mitotic cycle of exposed Pp, the change in activation energy is established, and this activation energy is found to be in the range of enzyme-catalyzed reactions. The influence of frequency on Pp is also incorporated into the model, and a stronger coupling of the electromagnetic field is seen as the frequency decreases.

5637 THE BIOLOGICAL EFFECTS OF MAGNETIC FIELDS ON MAN. (Eng.) Ketchen, E. E. (Oak Ridge Natl. Lab., P.O. Box X, Oak Ridge, TN 37830); Porter, W. E.; Bolton, N. E. *Am Ind Hyg Assoc J* 39(1): 1-11; 1978. (44 refs)

The biological effects of stationary magnetic fields (SMF) are reviewed. Although little is known about the effects of SMF on man, Soviet studies on workers employed in the fabrication of permanent magnets indicate bradycardia, tachycardia, and a decrease in arterial blood pressure along with irritability, fatigue, occasional dizziness, altered appetite, and headache. Studies with animals indicate that SMF can affect central nervous system activity, appetite, behavior, aging, and heart action as well as produce changes in various organs and tissues, including blood. Soviet workers observed brain lesions in a rabbit after exposure to a SMF, although the lesions were later shown to be due to enhancement of the effect of an endemic infection by exposure to a SMF. The lowest detectable limit of interaction between higher animals and SMF is 80-100 G. Exposure limits for man of 200 G for the whole body or head and 2,000 G for arms and hands have been proposed for extended exposures. For short exposure periods (minutes), 2,000 G for the whole body or head and 20,000 G for the arms and hands have been proposed. It is recommended that people with a history of mental problems, those with implanted electronic medical devices, pregnant women, and persons with chronic health problems, such as, sickle cell anemia or heart trouble be excluded from exposure to SMF. Apart from the possible harmful effects of a SMF on man, there may be useful effects in the treatment of diseases. For example, the French are working with magnetic fields for the treatment of cancer, sleeping sickness, and atherosclerosis.

5638 EFFECTS OF MICROWAVES ON ORGANISMS. GYMNOCLIDIUM BREVE AS A MODEL SYSTEM. (Eng.) Martin, D. F. (Dept. Chemistry and Physics, Univ. South Florida, Tampa, FL 33620); Martin, B. B.; Bloch, S. C. *J Environ Sci Health A12(10): 523-530; 1977.* (5 refs)

The Florida red tide organism, *Gymnodinium breve* (Gb), a neritic dinoflagellate, was used as a model system to study the effects of continuous wave microwave radiation at a frequency of 2,450 MHz and at power levels of up to 50 W. Inasmuch as this single-celled organism is motile and dispersed in sea water medium, it seemed unlikely that the orga-

nisms could achieve a temperature significantly different from the medium; moreover, the effect of simple temperature alteration was known for this organism. Preliminary experiments with nonirradiated organisms indicated no statistically significant loss of cell numbers as a result of experimental manipulation or simple temperature rises of up to 6°C under the conditions used. When the cells were irradiated, little effect on cell survival was noted for total energies of up to 0.08-0.09 kJ/cm³; however, the fraction of surviving cells decreased to 0-4% of control values at total energies of greater than 0.1-0.12 kJ/cm³. Cell survival 1 wk after irradiation was related to total energy absorbed and not to the power level used since there was no statistically significant difference between the use of lower power levels for a longer period or higher power levels for a shorter duration provided the total energy absorbed was the same. Over a 48-hr period, a first-order decrease in cell numbers was observed, and beyond 48 hr, the cells appeared to agglomerate. The above results indicate the usefulness of Gb as a model system and show that microwave radiation is disruptive to Gb cells even when low power levels are used.

5639 MICROWAVE ISSUE HEATS UP. (Eng.) Wade, N. (No affiliation given). *Trends Biochem Sciences* 3(2): N33-N34; 1978. (0 refs)

Differences between microwave safety standards in the United States and the Soviet Union are discussed. The acceptable level of microwave exposure in the United States of 10 mW/cm² is based on the conception that the principal biologic effects of microwaves are exerted through heating of tissues, and calculations suggest that the human body can accept 10 mW/cm² without an increase in body temperature. The Russian standard of 0.01 mW/cm² is based on observations that low level microwave exposure can cause headaches, irritability, sleep disturbances, loss of sexual desire, and general malaise. American scientists have been generally unable to establish such effects. In the United States, the bulk of research into the biologic effects of microwaves has been supported by the military services, which have an enormous vested interest in maintaining the 10 mW/cm² safety level, and there is a conspiracy theory that the Department of Defense has therefore organized its research to support the existing standard. On the other hand, Russian biologists may perhaps be overaddicted to Pavlovian theories. Probably both approaches have their merits, and the intractability of the subject matter may be the chief reason for the American-Russian divergence.

5640 THE HYPING OF AMERICA (EDITORIAL). (Eng.) Bease, S. (No affiliation given). *Microwaves* 17(2): 38; 1978. (1 ref)

The Zapping of America; Microwaves, Their Deadly Risk and the Cover-Up is critically discussed. The book attempts to prove that an electromagnetic en-

vironment has been established in the United States that is hazardous to human health. In addition, it charges that a massive effort has been made by industry and military officials to cover this up. The book is a complex maze of scientific and pseudo-scientific information and raises more questions than it answers. The author concludes that the book and the T.V. appearances of its author, Paul Brodeur, render a disservice to many dedicated biophysics researchers.

5641 ELECTROMAGNETIC STRETCH OF INDIVIDUAL MUSCLES IN BEHAVING PRIMATES. (Eng.) Wolpaw, J. R. (Lab. Neurophysiology and Section on Technical Development, Natl. Inst. Mental Health, Bethesda, MD 20014); Colburn, T. R. *Brain Res* 141 (1): 193-196; 1978. (5 refs)

An electromagnetic technique for inducing stretch of individual muscles in *Macaca mulatta* primates by the direct application of calibrated force unaccompanied by other stimuli is described. The technique involves the use of an external electromagnet to apply force to a small piece of permeable metal chronically imbedded in the musculotendinous junction. A monkey with the implant in the flexor carpi ulnaris was placed in a primate chair, with the upper arm restrained by a cuff, the elbow flexed to 90 degrees, and the forearm passing through an electromagnet spool. The forearm was positioned inside the spool so that the implant was half inside the proximal end of the coil and as near to its longitudinal axis as possible. The arrangement permitted no significant axial or radial movement of the forearm relative to the coil. An analysis of electromyographs (EMG) of tendon jerks following the onset of 100 msec (7 msec rise time), 90 g, direct current stretch delivered at pseudo-random 3-6 sec intervals indicated a correlation between tendon jerk amplitude and background EMG activity. When the inactive muscle was subjected to a 3.6 sec, 77 g peak, 60-Hz full wave rectified stretch, an initial stretch reflex and a subsequent tonic vibratory response were observed. The above technique has a variety of possible applications in research at peripheral, segmental, and suprasegmental levels.

5642 EFFECT OF MICROWAVE OR WATERBATH HYPERTHERMIA ON TUMOR GROWTH (MEETING ABSTRACT). (Eng.) Sparks, F. C. (Veterans Hosp., Sepulveda, CA). *Hosp Topics* 56(1): 18; 1978. (2 refs)

The effect of total body microwave hyperthermia and total body waterbath hyperthermia on local tumor growth in mice was compared to select an optimal form of hyperthermia for adjuvant chemotherapy breast cancer programs. Tumors were implanted subcutaneously in BALB/C female mice, which were divided into three treatment groups after the tumors had grown. One group served as a control, and the other two groups were treated with hyperthermia to 41.5°C for 60 min. One of the groups treated with hyperthermia was heated by immersion to neck level in a waterbath, while the other group was heated in

a Litton microwave oven modified for biologic use. At 16 days after tumor implantation, the tumor volume in control mice had grown 56% compared with 32% in mice treated by microwave hyperthermia and 24% in mice treated by waterbath hyperthermia. The effects on tumor size and animal survival were transient. It is concluded that the simpler whole body waterbath hyperthermia is as effective as whole body microwave hyperthermia, and it is suggested that this form of adjuvant therapy may have a place in treating women with Stage 2 breast cancer.

- 5643 ELECTROMAGNETIC RHEOANGIOMETRY: AN EXTENSION OF SELECTIVE ANGIOGRAPHY. (Eng.) Kolin, A. (Biophysics Lab., UCLA Center for the Health Sciences, Los Angeles, CA 90024); MacAlpin, R.; Steckel, R. *Am J Roentgenol* 130(1): 13-23; 1978. (12 refs)

An electromagnetic rheoangiometric technique is described. A harmless magnetic field produced by an extracorporeal magnet induces in human blood vessels electrical signals, which carry information about regional blood flows. Loop probes of hairlike consistency equipped with fine electrodes are introduced percutaneously and selectively into the vasculature through angiographic catheters to pick up these magnetically induced signals at selected loci. In addition to a continuous record of phasic blood flow, the loop sensors provide signals that measure variations in vascular diameters, thus yielding a continuous record of active and passive vasomotion. Coupled with blood pressure recordings, these data permit the determination of the elastic constants of blood vessels *in situ*. The capabilities of electromagnetic rheoangiometry for providing continuous records of these vascular parameters are illustrated with tracings in dogs, using multichannel recorders, which provide continuous information of arterial blood pressures, instantaneous and mean vascular diameter changes simultaneously in two nonadjacent arteries.

- 5644 A NEW HAZARD IN THE USE OF AN EXTERNAL DEMAND PACEMAKER. (Eng.) Hasin, Y. (Intensive Cardiac Care Unit, Hadassah Medical Center, Jerusalem, Israel); Mahler, Y.; Rogel, S. *J Electrocardiol* 11(1): 93-96; 1978. (16 refs)

Capacitive coupling of 50-Hz fields from the environment was found to inhibit ventricular pacing by a Medtronic model 5880A external demand pacemaker. The inhibition lasted as long as the metal coverplate of the pacemaker was touched by the physician's bare hands. The electrical field measured during the time that pacing was inhibited was 0.1 V/10 cm. When all of the electrical cables were disconnected from the mains, the electrical field was reduced to 0.002 V/10 cm, and the above described interference with pacemaker function could not be elicited anymore. However, even under these conditions, touching the metal coverplate with bare hands caused activation of the sensing mechanism, resetting the timing. Such inhibitions due to handling of the pacemaker by medical personnel

were repeatedly observed in all of six such pacemakers used routinely. The above pacemaker malfunction could not be elicited in a model 5840 external pacemaker, which has a plastic coverplate. Pacer inhibition in units with metal coverplates was demonstrated to be induced by capacitive coupled 50-Hz fields from the environment, activating the sensing mechanism through the metal coverplate.

- 5645 THE TRAJECTORIES OF PARTICLES SUSPENDED IN ELECTROLYTES UNDER THE INFLUENCE OF CROSSED ELECTRIC AND MAGNETIC FIELDS: POSSIBLE EXPLANATION OF THE SENSITIVITY OF ORGANISM TO MAGNETIC FIELDS. (Eng.) Gunter, R. C. (Dept. Physics, Holy Cross Coll., Worcester, MA 01610); Bamberger, S.; Valet, G.; Crossin, M.; Ruhnstroth-Bauer, G. *Biophys Struct Mech* 4(1): 87-95; 1978. (15 refs)

Various types of particles suspended in electrolytes were exposed to crossed electric and magnetic fields to study the mechanism by which certain animals orient themselves in the earth's magnetic field. When non-conducting polystyrene beads, quartz powder, blood cells (erythrocytes and thrombocytes), metallic particles, or particles made of 1% Agarose or of methylcellulose were suspended in an electrolyte and brought into crossed magnetic and electric fields of magnitudes as low as 50×10^{-4} T and 5 V/m, respectively, the particles deviated in the central part of the electrophoresis chamber of a standard Zeiss Cytopherometer with a component vertical to both fields. The vertical deviation was very similar for all particles despite their different nature. The direction and magnitude of the deviation were sharply at variance with what would be expected by the action of the Lorentz force on the surface of the particles. The magnitude of the deviation depended on the magnetic and electric field strength, the ion concentration of the suspension medium, and the geometry of the chamber. The above results are compatible with streaming of the electrolyte, which is mainly caused by inhomogeneities of the electric field in the electrophoresis chamber. The magnitude of the effect is high enough to occur under physiologic conditions, and it is suggested that magneto-electrophoretic streaming might eventually act as a transducer mechanism, which could explain the ability of some animals to orient themselves in the geomagnetic field.

- 5646 EFFECT OF COAGULATING AND CUTTING CURRENT ON A DEMAND PACEMAKER DURING TRANSURETHRAL RESECTION OF THE PROSTATE. A CASE REPORT. (Eng.) Batra, Y. K. (Dept. Anaesthesiology, Post Graduate Inst. Medical Education and Res., Chandigarh, India); Balli, I. M. *Can Anaesth Soc J* 25(1): 65-66; 1978. (9 refs)

The effects of coagulating and cutting current on a demand pacemaker during transurethral resection of the prostate are reported. The application of prolonged cutting current from a surgical diathermy unit operating in the frequency range of 1-3.5 MHz

with modulation at 120 Hz caused interference with a Medtronic series 5945 demand pacemaker, leading to a period of asystole. When coagulating current was applied for hemostasis, pacemaker function was not affected. The resection was completed with short bursts of cutting current that did not modify pacemaker function. This case emphasizes the need for vigilance in the care of patients with demand pacemakers requiring transurethral resection.

- 5647 ELECTRICAL AND BIOLOGICAL EFFECTS OF TRANSMISSION LINES: A REVIEW. (Eng.) Biological Studies Task Team (Bonneville Power Administration, Portland, OR). 68 pp.; 1977. [available through Bonneville Power Admin., U.S. Dept. Interior, Portland, OR].

A review of studies on the biologic effects of electrical power transmission lines is presented. EPA issued a request for data to determine if there is a need to provide guidance for radiation standards for transmission lines above 700 kV, and a preliminary analysis of the data did not identify any acute detrimental health or environmental effects. Soviet studies on extremely high voltage substation workers reported physiologic effects, such as, greater variability of pulse and arterial blood pressure and reduced sexual potency among workers exposed to 50-Hz fields with intensities ranging from 2-26 kV/m. Other than reports involving some substations in Spain, the complaints by Soviet workers have not been reported for substation workers in other countries. A few studies have described possible biologic effects associated with exposures to magnetic fields similar to those encountered under transmission lines. For example, a delayed increase in serum triglycerides was found in 10 men exposed to a magnetic field of 1 G at 45 Hz for up to 24 hr. Very little research has been specifically conducted to determine if organisms are affected by the electric fields and ion currents of direct current transmission lines. Preliminary findings from a study of the Oregon portion of the Celilo-Sylmar direct current transmission line do not indicate that there are any significant adverse effects on natural vegetation, crops, wildlife, and domestic animals.

- 5648 IMPLANTABLE ELECTROMAGNETIC FIELD PROBES IN FINITE BIOLOGICAL BODIES. (Eng.) Mousavinezhad, S. H. (Ph.D. dissertation, Michigan State Univ, 1977); 180 pp. [available from Xerox Univ. Microfilms, Ann Arbor, MI 48106, Order No. 77-25, 270]. (24 refs)

Theoretic and experimental results of a study on a dielectrically-coated small spherical probe used to measure induced electromagnetic fields in conducting (biological) bodies of finite extent are presented. After deriving the general relation between the output voltage of a probe and the induced electric field in a volume conductor, the receiving characteristics of an insulated spherical probe immersed in a uniform electric field inside a conducting body were studied. The normalized

effective diameter of the probe was shown to be nearly independent of the parameters and dimension of the conducting body when a relatively thick coating of insulating material was used on the probe. It was also shown that for thick coatings with dielectrics of low dielectric constant the input impedance of the spherical probe becomes nearly independent of the electrical parameters and the dimension of the finite biologic body. Some experimental results on the input impedance of the spherical probe were obtained, and there was generally good agreement between theory and experiment. A few measurements of actual field intensity inside finite bodies were also performed.

- 5649 EFFECT OF STATIONARY MAGNETIC FIELD ON THE GROWTH AND ENZYMATIC ACTIVITY OF STAPHYLOCOCCUS AND ON THE DEVELOPMENT OF STAPHYLOCOCCUS INFECTION. (Rus.) Kuz'minskii, B. N. (Voroshilovgrad Medical Inst., Voroshilovgrad, USSR); Nuromskaya, O. A.; Semenikhina, G. S.; Abakarov, M. Kh. *Zh Mikrobiol Epidemiol Immunobiol* (10): 140-141; 1977. (0 refs)

The effects of stationary magnetic field (830-880 G) on the growth and enzymatic activity of *Staphylococcus aureus* strain 209 and on the course of *S. aureus* infection in white mice were studied. Exposure to the magnetic field for 2.5 hr did not cause any significant change in the enzymatic activity (unspecified), but it significantly stimulated the growth of *S. aureus*. For seeding doses of 10^{-8} /ml and 10^{-9} /ml, the colony counts were 405 ± 8.8 and 105 ± 13.4 , respectively, after the exposure, vs. 264 ± 20 and 57 ± 18 in the non-irradiated control. Forty mice were infected intraperitoneally with *S. aureus* ($6,750,000,000$ cells) after which 20 mice received whole-body irradiation in the stationary magnetic field daily (dose unspecified), and all 40 animals were examined morphologically 6 wk after the infection. Compared with the nonirradiated control, the infection was more serious and tended to generalize in the irradiated mice. Abscesses of the liver, kidneys, and perirenal region were seen in all experimental animals, while the abscesses clustered mainly around the site of infection in the control animals. The microscopic changes observed in the liver and kidneys (e.g., dilatation of veins with stasis, focal hemorrhage, destruction of the walls of small vessels with desquamation of the endothelium and hemolysis, albuminoid degeneration and fatty infiltration) were more pronounced in the exposed animals than they were in the control.

- 5650 APPLICATION OF MAGNETIC-BIOLOGICAL EFFECTS IN NEUROSURGERY. (Ger.) Kikut, R. P. (Res. Inst. Traumatology Orthopedics, Ministry of Public Health of the Latvian SSR, Riga, USSR); Liepa, M. E. *Zentralbl Neurochir* 38(1): 97-104; 1977. (5 refs)

Recent achievements in the study of the applications of constant magnetic fields in the treatment of intracerebral aneurysms and gliomas are reviewed.

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Experiments using animals with cerebral aneurysms showed that constant magnetic fields influence the circulating blood, causing thrombus formation in the anode zone and thrombolysis in the cathode zone. Studies on the therapeutic applications of magnetic fields in the treatment of brain tumor patients are concerned with the influence of magnetic fields on the unspecified immunity and tumor cells and with local thermal effect on the tumor. Training, activation, and stress are the three phases of action of constant magnetic fields on the brain. The first phase is characterized by normal leukocyte count with slight increase of the segmented cell count and reduction of the lymphocyte count; the second phase is characterized by an increased leukocyte count to 7,000-9,000 mm³, a slightly increased lymphocyte count, and a slight reduction of the neutrophil count. The third phase features the exhaustion of the glucocorticoid release by the adrenals. Magnetic fields have shown direct therapeutic effect on human glioblastomas, and they also have been found to increase the sensitivity of the tumors to certain cytostatic drugs.

5651 **EFFECT OF PULSATING ELECTROMAGNETIC ENERGY AND CONVENTIONAL SHORT-WAVE DIATHERMY IN THE CONSERVATIVE THERAPY OF OSTEOARTHRITIS.** (Ger.) Singer, F. (Rehabilitationszentrum der Pensionsversicherungsanstalt der Arbeiter, Grieskirchner Strasse 43, A-4701 Bad-Schallerbach, Vienna, Austria); Schieler, K. *Wien Med Wochenschr* 128(1): 49-51; 1978. (9 refs)

The effects of short-wave diathermy (15 min/day) and pulsating ultra-high-frequency electromagnetic field treatment (Diapulse model D-104 A, carrier frequency 27.12 MHz, pulse frequency 80-600 Hz, pulse duration 65 μ sec, 970 W, up to 90 min/day) were studied in 150 patients (men and women, aged 50-65 yr) with primary and secondary osteoarthritis. The patients were subdivided into five groups of 30 persons each. Group 1 received only physiotherapy; Group 2 received physiotherapy plus Diapulse treatment (90 min/day on the hips, liver, and left adrenal); Group 3 received physiotherapy plus Diapulse treatment on the hips (2x 25 min/day); Group 4 received physiotherapy with conventional short-wave diathermy; and Group 5 received physiotherapy with the Diapulse apparatus shut off (placebo). The therapeutic effect was assessed from the difference of joint mobility index (on a scale of 1 to 122) and of the rheumatism index in which the subjective complaints are also considered (on a scale of 1 to 188). The average reduction of the rheumatism index (improvement) was 4.45 in Group 1, 19.25 in Group 2, 11.01 in Group 3, 13.60 in Group 4, and 4.45 in Group 5. The average reduction of the joint mobility index (improvement) was 2.2 in Group 1, 15.6 in Group 2, 6.97 in Group 3, 11.61 in Group 4, and 2.2 in Group 5. The findings indicate the definite favorable effect of Diapulse treatment of the hips, liver, and adrenal regions compared with Diapulse treatment of the hip alone and with conventional diathermy apparatus.

5652 **THERAPEUTIC EFFECT OF HERTZIAN WAVES OF VERY LOW INTENSITY.** (Fr.) Debelle, M. (Nouvelle Clinique de la Basilique, Departement des Affections Osteoarticulaires, 1080 Brussels, Belgium); Lorthioir, J.; Berghmans, M.; Carion, J.; Rosenfeld, J. *Brux Med* 57(12): 551-563; 1977. (0 refs)

Experience with the therapeutic use of low-intensity contact radiation source (Flexible Electromagnetic Unit) is presented. The principal characteristics of the apparatus are a carrier frequency of 27.12 MHz, a peak energy of 0.5 W, a pulse frequency of 200-600 Hz, and a pulse duration of 1.6-4.9 msec. The antenna is molded on the body surface to be treated. The apparatus, which generates no thermal effect, was used successfully in the treatment of patients with various diseases. These patients, many of whom had been treated unsuccessfully by other methods, included an 84-yr-old man with arterial ulcer; two women, aged 39 and 50 yr, with inflammation of the hypoderm; patients with varicose veins; a 48-yr-old woman with eczema; patients with arthritis; and patients with bone fractures and other traumas. The patients were usually irradiated 1.5-6 hr daily for several wk.

5653 **RISK FROM EXPOSURE TO RADIOFREQUENCIES AND MICROWAVES.** (Ita.) Bini, M. (Istituto di Ricerca sulle Onde Elettromagnetiche C.N.R., Florence, Italy); Checacci, A.; Ignesti, A.; Milanta, L.; Rubino, N.; Cicchella, G. *Med Lav* 68(5): 321-339; 1977. (67 refs)

The biophysical aspects and effects of radio frequency and microwave radiation are reviewed. The thermal effects resulting from exposure to microwaves may cause structural and functional changes in the gonads (reduction of spermatogenesis), alterations in the menstrual cycle, abortion, and fetal malformations, and cataracts of the eyes. Nonthermal effects may include an increase of slow waves, reduction of alpha waves, visual hallucination, variations in olfactory and auditory sensitivity, ECG changes, bradycardia or tachycardia, hypertension or hypotension, increased capillary resistance, reticulocytosis, hypohemoglobinemia, reduced osmotic resistance, neutrophil and eosinophil leukocytosis, lymphocytosis, monocytosis, hyperthyroidism, increased adrenal activity, reduced corticosteroid levels in the blood, reduced glucocorticoid activity, alteration of the blood cholinesterase activity, and changes in the glucose, cholesterol, and lipid levels of the blood. The review is preceded by a short introduction to the biophysics of radiowaves.

5654 **ENVIRONMENTAL MICROWAVE RADIATION. SAFETY RULES NEEDED. NO FINAL SOLUTION TO THE DOSIMETRY PROBLEM.** (Nor.) Hvinden, T. (Forsvarets Forskningsinstitut, Norway). *Teknisk Ukeblad* 125(1): 6-7, 10; 1978. (0 refs)

The occurrence and general biologic aspects of radar and radio frequency waves in the environment

are reviewed. The energy density is usually in the milliwatt range near radio transmitter stations. At greater distances, the energy density is considerably influenced by the orographic conditions. Therefore, the measurement of the energy density in open air does not always yield reliable results, especially for the actual energy density inside the body. The absorption of radiowaves by the body is frequency-dependent, increasing with increasing frequency. At an atmospheric energy density of 10 mW/cm^2 , the energy absorbed by the human body is 0.02 W/kg at 10 MHz frequency, 1.9 W/kg at 100 MHz (near the resonance frequency), and 0.44 W/kg at 1,000 MHz (above the resonance frequency).

5655 MICROWAVE AND RADIOPHREQUENCY RADIATION. (Nor.) Pleyn, H. (No affiliation given). *Teknisk Ukeblad* 125(1): 9-10; 1978. (0 refs)

General problems of microwave radiation are discussed in connection with the setting of exposure standards. The hygienic exposure standard adopted in the USA is 10 mW/cm^2 for daily 8-hr exposure, vs. $10 \mu\text{W/cm}^2$ in the USSR. The discrepancy is due to the different principles upon which these standards were established. While the US standard is based on the thermal effect of microwaves, the USSR standard was based on the subtler nonthermal biologic effects, including the effects on the central nervous system. The existence of a threshold dose of microwave radiation is a fundamental question in hygienic studies. A potential source of microwave radiation pollution is seen in solar energy collection by means of power plants in space because the energy must be beamed to earth in a focussed bundle.

5656 EFFECT OF AN ELECTROMAGNETIC FIELD OF LOW FREQUENCY (50 Hz) ON THE FUNCTIONAL STATE OF THE HUMAN BODY. (Rus.) Dumanskil, Iu. D. (Kiev Scientific Res. Inst. General and Communal Hygiene, Kiev, USSR); Popovich, V. M.; Koziarin, I. P. *Gig Sanit* (12): 32-36; 1977. (0 refs)

The biological effects of electrical fields of 50 Hz frequency were studied in 34 volunteers aged 23-47 yr. Group 1 (5 men, 5 women) was exposed to a 5 kV/m -electrical field for 2 hr daily 6 times a week during a 30-day period. Group 2 (6 men, 6 women) was exposed to 12 kV/m -field $3 \times 30 \text{ min/day}$ at 1-hr intervals for 6 consecutive days, and Group 3 (6 men, 6 women) was exposed to a field of $15-16 \text{ kV/m}$ under the same conditions as Group 2. Observed in Group 3 were increased skin temperature on the forehead, chest, palms; reduced skin temperature of the lower limbs; increased amplitude of the evoked brain potentials by 11.2-29.2% compared with the values found before the exposure, reduced heart rate from 82.14/min to 75/min; reduced maximal arterial pressure at rest (value not given), increased R-R section of the ECG from 0.73 to 0.80 ($P<0.05$), increased T wave amplitude during hypoxemia (from 0.30 to 0.40 mV, $P<0.05$); increased blood cholinesterase activity (135.8 $\mu\text{g/min}$ vs.

114 $\mu\text{g/min}$, $P<0.05$) and of blood glucose level from 86.7 mg\% to 104 mg\% ($P<0.05$). No parameters tested showed significant changes in Groups 1 and 2. The findings indicate that in the case of exposure for 2 hr daily, a field intensity of 5 kV/m is the highest no-effect intensity, vs. 12 kV/m in the case of intermittent exposure ($3 \times 30 \text{ min/day}$).

5657 BIOLOGICAL EFFECTS OF MICROWAVES. RECONCILIATION OF DIFFERENT APPROACHES. (Nor.) Devik, F. (Statens Institut for Strelehygiene, Osteendalen 25, 1345 Osteras, Norway). *Teknisk Ukeblad* 125(1): 7-8; 1978. (0 refs)

The different approaches used to determine standards for microwave exposure in the USA and the USSR and other east European countries are discussed. The hygienic standard of 10 mW/cm^2 , adopted in the USA, was based on the thermal effects of microwaves, while the USSR and other eastern block countries arrived at considerably lower energy level standards on the biological effects of microwaves, especially long-term and central nervous system effects. Soviet researchers demonstrated disturbances in conditioned reflexes and changes in the behavioral pattern ("most likely in animals" - transl.) under the effect of radiofrequency radiation of low intensity having no thermal effect. Changes in the EEG were also observed. Frequent activation of the adaptive mechanism of the body is believed to lead to its exhaustion and general asthenia. Initial steps have been taken to narrow the gap between the two different approaches to the hygienic standardization of microwave exposure.

5658 LOCAL MICROWAVE HYPERTHERMIA (43° C) AND STIMULATION OF THE MACROPHAGE AND T-LYMPHOCYTE SYSTEMS IN TREATMENT OF GUERIN EPITHELIOMA IN RATS. (Eng.) Szmigelski, St. (Center for Radiobiology and Radioprotection, Warsaw, Poland); Janiak, M.; Hryniewicz, W.; Jeljaszewicz, J.; Pulverer, G. *Z Krebsforsch* 91(1): 35-48; 1978. (68 refs)

The effect of local microwave hyperthermia (LMH) combined with immunopotentiating (IP) substances on the growth of Guerin epithelioma in Wistar rats as well as on the rat immunologic system was investigated. Rats bearing Guerin epithelioma were exposed to three or six sessions of $2,450\text{-MHz LMH}$ (tumor temperature, 43° C) for 45 min per session on wk 3 or 5 after tumor cell implantation. In some rats, LMH was combined with the administration of IP substances, such as, purified Streptolysin (1 mg/kg) or *Corynebacterium parvum* (CP) (1 mg/kg) injected three times weekly on wk 4 and 6 after tumor cell implantation. Exposure to LMH inhibited the growth of Guerin tumors, and the effect was enhanced by combined treatment with IP substances. The combined application of LMH and CP resulted in the complete disappearance of 9 of 12 tumors; whereas, LMH and IP substances applied separately resulted in the eradication of 4 out of 12 and 2 out of 12 tumors, respectively. Exposure to LMH also resulted in a stimulation of the reactivity of the thymus-derived lymphocyte and macrophage systems

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of the rat, enhancing both nonspecific and specific immune responses. The role of immunostimulation by LMH is stressed as an important factor in the tumor-inhibiting effect of hyperthermia in addition to the well-known selective heat killing effect of microwaves on neoplastic cells.

- 5659 EFFECT OF MAGNETIC FIELD ON CHICK MORPHOGENESIS. (Eng.) Joshi, M. V. (Dept. Zoology, Univ. Poona, Poona 411 007, India); Khan, M. Z.; Damle, P. S. *Differentiation* 10(1): 39-43; 1978. (19 refs.)

The effect of a magnetic field on chick morphogenesis was investigated. Fresh fertilized eggs of White Leghorn chickens were incubated to the definitive primitive streak stage (Hamburger-Hamilton [H.H.] Stage 4). The embryos were mounted, cultured, and exposed to a homogeneous magnetic field of $5,000 \pm 200$ Oe for 1 hr. Controls were maintained simultaneously without the magnetic field. The experimental and control embryos were further incubated for 24 hr to obtain the H.H. Stage 12 in controls. The experimental embryos were considerably retarded, as evidenced by a shortening of the embryonic long axis in 16 embryos as well as by other malformations. Microcephaly only was observed in 6 of 25 exposed embryos and an open neural tube only in 11 of 25 exposed embryos. Microcephaly and open neural tube were observed in 8 of 25 exposed embryos. Diffused somites were observed in 18 of 25 exposed embryos. In 12 experimental embryos, the heart was not formed; out of 13 in which the heart did develop, it was slightly displaced and dilated in about half of them. All of the controls developed normal to H.H. Stage 12. Histologic observations of the neural structures in the sectioned experimental embryos showed an increase in the number of dividing cells and their dispersed distribution throughout the neuroepithelium. The malformations recorded are attributed to the environmental stress effect caused by the magnetic field as manifested by its effect on mitotic activity, interkinetic nuclear migration in neuroepithelium, and cell locomotion in general.

- 5660 NONTHERMAL EFFECTS OF MILLIMETER MICROWAVES ON YEAST GROWTH. (Eng.) Grundler, W. (Gesellschaft fuer Strahlen- und Umweltforschung, Neuherberg, W. Germany); Keilmann, F. *Z Naturforsch* 33c(1/2): 15-22; 1978. (10 refs.)

The influence of coherent microwave irradiation in the frequency range near 42 GHz on the growth of aqueous yeast cultures was investigated. To avoid thermal effects of irradiation, yeast cell cultures in stirred aqueous suspension were used. Over a period of 90 days, 67 growth experiments were performed. Weak microwave irradiation ($0.1-1 \text{ mW/cm}^2$) of the aqueous yeast cultures affected their growth rate in a frequency selective manner. Depending on the frequency, both increases and decreases in the growth rate were observed. A multiplet of resonances between 41.64 and 41.79 GHz were observed, with each of them having a resonance bandwidth of

only about 10 MHz. Whereas unirradiated control cultures showed growth rate data scatter of only $\pm 3\%$ from the mean value at a given temperature, irradiated cultures showed deviations from the mean growth rate as high as 29%. Simple thermal effects are excluded, and it is suggested that the findings support theoretic predictions of coherent molecular oscillations activating metabolic processes.

- 5661 EFFECTS OF GRAVITATIONAL AND MAGNETIC FIELDS ON TRANSPLANTED NEUROBLASTOMA VASCULARITY. (Eng.) Batkin, S.; Tabrah, F. L. (John A. Burns Sch. Medicine, Univ. Hawaii, Honolulu, HI 96822). 5 pp., 1977. (available through National Technical Information Service, Springfield, VA 22161, Document No. A77-457891. (13 refs.)

Subcutaneously transplanted neuroblastomas that were denervated at the tumor implantation site in A/J mice were subjected to gravitational and/or magnetic forces to determine if these forces could enhance the impairment of tumor vascularization produced by denervation. Exposure to either a gravitational force of 4 gravity units or to alternating (60 Hz) magnetic fields of 1.2 or $4 \times 10^{-3} \text{ Wb/m}^2$ resulted in impaired vascularity and a greater extravasation of blood with associated tumor necrosis. The combination of hypergravity (5 gravity units) and a $4 \times 10^{-3} \text{ Wb/m}^2$ alternating magnetic field over a 15-day period resulted in definite macroscopic changes. The tumors in exposed animals were readily peeled out, while control tumors infiltrated into surrounding tissues. The average tumor volume was 410 mm^3 in the exposed animals compared with 630 mm^3 in controls. Microscopic analysis again revealed previously noted blood stasis in the experimental tumor group with extravasation of red blood cells; however, the contrast to the control group was not as dramatic as noted with either force alone. Neuroblastoma cells *in vitro*, which were exposed to a magnetic field of $3.2 \times 10^{-2} \text{ Wb/m}^2$ for 48 hr showed no definite growth changes, suggesting an effect of the field forces on the host. However, the exposure of *Tetrahymena pyriformis* to a magnetic field of $6 \times 10^{-3} \text{ Wb/m}^2$ resulted in a marked decrease in cell division with associated morphologic changes in both synchronous and log-phase cultures at 80 min and 49 hr, respectively. In general, the results suggest that host-tumor relationships can be affected by gravitational and weak alternating magnetic fields via vascular changes. Single cell organisms may also be modified by weak alternating magnetic fields.

- 5662 ELECTROMAGNETICALLY INDUCED FLUID STREAMING AS A POSSIBLE MECHANISM OF THE BIOMAGNETIC ORIENTATION OF ORGANISMS. (Eng.) Bamberger, S. (Max-Planck-Institut fuer Biochemie, Abteilung fuer Experimentelle Medizin, Martinsried bei Munchen, W. Germany); Valet, G.; Storch, F.; Ruhstroth-Bauer, G. *Z Naturforsch* 33(1/2): 159-160; 1978. (7 refs.)

Electromagnetically induced fluid streaming in the chamber of a Zeiss cytophotometer was investigated

as a possible mechanism of the biomagnetic orientation of organisms. The electrolyte in the chamber consisted of a solution containing 1 molar copper sulfate and 0.5 molar sodium sulfate. The velocity of suspended particles (human erythrocytes with their natural charge removed by neuraminidase treatment) was used as an indicator of fluid streaming. The fluid and suspended particles were simultaneously exposed to crossed magnetic and electric fields of $0.40 \pm 0.01 \times 10^{-4}$ tesla and $500-1,590 \text{ mA/cm}^2$, respectively. With the chamber oriented so that the geomagnetic field vector was parallel to the y-axis of the chamber, a fluid stream in the direction of the z-axis was observed. The geomagnetic field strength, calculated from the velocity measurements, was $0.46 \pm 0.05 \times 10^{-4}$ tesla (13% greater than the measured value). The results indicate that both the direction and intensity of the geomagnetic field can be sensed within the chamber of a Zeiss cytophotometer. This suggests that electromagnetically induced fluid streaming might play a role in the perception of the geomagnetic field by organisms, although it is not clear in which organ the perception occurs. A basic requirement for such an organ would be an anisotropy of cells or cellular structures. The nervous system with its parallel axons, or specific cells associated with the nervous system, could thus be possible locations of the sensitivity towards magnetic fields.

5663 OPTIMIZING THE HEAT TREATMENT OF TUMORS
BY MICROWAVES (MEETING ABSTRACT). (Eng.)
Joines, W. T. (Duke Univ., Durham, NC 27706). *Am J Roentgenol* 130(1): 188; 1978. (0 refs)

Guidelines for optimizing the delivery of heat to a tumor by microwave radiation are described. The optimum microwave frequencies for heating cancerous tissue are approximately 0.5 to 1.5 GHz. Using a variety of direct-contact applicators, a complete system for automatically controlled microwave heating of cancerous tissue was developed. Heating was at a selected location to within an accuracy of $\pm 0.1^\circ\text{C}$. The temperature was monitored by tissue-implantable thermistor probes oriented at right angles to the microwave electric field, and sample temperature readings were made only during 1 msec periods every 100 msec when the microwaves were off. During the off period, a temperature reading was taken and stored in a sample-and-hold circuit until the next off period, when the reading was updated. The thermal time constant of the system was sufficiently long that no appreciable temperature change occurred between samples. In addition, the off period was long enough to allow the microwaves to decay to a negligible value before the sample was finalized. Rectification effects were avoided, since no microwaves were present when the readings were taken. The tissue-implantable thermistor probe continuously monitored the temperature at a selected site within the heated tissue. When the temperature at that site reached a pre-selected level, a signal was fed back through the thermal regulator to the microwave source to adjust the output power and keep the temperature within $\pm 0.1^\circ\text{C}$.

of the preselected level. One of the direct-contact applicators was a double-ridged waveguide horn antenna that operated in the 0.9 to 4 GHz range. By placing aluminum adhesive tape directly onto the surface between the tissue and the horn antenna, but leaving an opening that defined the area to be irradiated, the aperture could be adjusted from about 8 by 12 cm up to the 17 by 22.75 cm opening of the horn antenna, while maintaining a uniform heating pattern across the aperture. For confining the microwave heating to smaller areas, a dielectric (titania) loaded horn antenna was developed that operated at 915 MHz and had a contact area of 9 cm^2 . Using this applicator, the power supplied by a 5-W, solid-state microwave oscillator was sufficient to produce a temperature rise of $1^\circ\text{C}/\text{min}$ in biologic tissue. Other applicators having a size, shape, or radiation pattern appropriate for clinical requirements are also discussed.

5664 THE BASIC CONSIDERATIONS OF R. F. THERMO-
THERAPY AND CLINICAL EXPERIENCE (MEETING
ABSTRACT). (Eng.) LeVeen, H. H. (State Univ. New
York, Brooklyn, NY 11203); Ahmed, N. *Am J Roentgenol*
130(1): 189-190; 1978. (0 refs)

The results of hyperthermic treatment for lung cancer patients are presented. A solid state 500-W amplifier with a crystal-controlled output at 13.56 MHz supplied the radiation. The treatment schedule consisted of a course of four 3-hr heating sessions with tumor crossfiring. Patients were infused with glucose during therapy and were covered to allow a fever of $38-39^\circ\text{C}$ to develop. Treatment continued until complete regression occurred. Following hyperthermic treatment, human lung tumors were examined histologically. Cancer cells were damaged or destroyed by heat, but the stroma of the tumor was also damaged. Collagen swelling was noted, and intense vasodilation occurred at the periphery of the tumor. Capillary damage caused diapedesis of red cells resulting in a heavy deposit of hemosiderin at the tumor's periphery. Plasma cells accumulated around the microvasculature, and polymorphonuclear leukocytes infiltrated foci of necrotic tumor cells. After a full course of therapy the microvasculature was destroyed with massive necrosis of the tumor. Infiltration of macrophages and lymphocytes into the tumor indicated an immune response. Nineteen patients have received a full course of therapy over one or more years. All showed immediate gain in strength and appetite, and regression of the tumor mass. Although some patients have died of distant metastases, all showed an extension of life expectancy. Half of the patients are still alive after 2 yr, and four are tumor free, while the others are under active therapy.

5665 PHOTO-INDUCED VOLTAGES IN SUSPENSIONS OF
CHLOROPLASTS ORIENTED IN A MAGNETIC FIELD
(MEETING ABSTRACT). (Eng.) Becker, J. F. (Dept.
Chemistry, New York Univ., New York, NY 10003);
Gaecintov, N. E.; Swenberg, C. E. *Biophys J* 21(3):
108a; 1978. (0 refs)

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The photovoltage of suspensions of magnetically oriented spinach chloroplasts using polarized light was measured. The magnitude of this photo-electromagnetic field (photoemf) depended on the polarization of the light and its direction of propagation with respect to the membrane planes. The photoemf was qualitatively interpreted in terms of the Dember effect, and its magnitude depended on a non-homogeneous generation of positive and negative charges and was thus a function of the absorption coefficient. The photoemf arose because of an inhomogeneous absorption of light within a chloroplast particle, which was due to the non-random orientation of chlorophyll molecules in the membranes. This gave rise to an inhomogeneous distribution of positive and negative charges along the direction defined by the propagation vector of the light (which was parallel to the vector joining the two electrodes). An electromagnetic field arose due to the diffusion of these charges but only when the mobility of the two charge carriers was unequal. The existence of a Dember-like solid state effect in a biologic system was demonstrated.

5666 BLOOD-BRAIN, BLOOD-VITROUS HUMOR AND PLACENTAL BARRIER MODIFICATION DUE TO MICROWAVE EXPOSURE (MEETING ABSTRACT). (Eng.) Frey, A. H. (Randomline, Inc., Huntingdon Valley, PA 19006); Coren, E. *Biophys J* 21(3): 110a; 1978. (0 refs)

The effects of microwave exposure on the blood-vitreous humor barrier of the eye and the placental barrier were investigated. Results showed a modification of the blood-vitreous humor barrier and lack of modification of the placental barrier under exposure to the energy.

5667 TREATMENT OF SOLID TUMORS BY RADIOFREQUENCY HEATING (MEETING ABSTRACT). (Eng.) Dickson, J. A. (Royal Victoria Infirmary, Newcastle upon Tyne, England). *Am J Roentgenol* 130(1): 189; 1978. (0 refs)

A modified diathermy technique, developed for heating solid tumors to 50°C without damage to skin and intervening normal tissues, is described. The portable machine has a radio frequency (RF) generator operating at a crystal-controlled frequency of 13.56 MHz (22 m wavelength) and an output of 400 W. The RF current is transmitted to the tumor via two coaxial cables, each terminating in a flat copper paddle electrode. The apparatus employs the condenser field technique whereby the tissue becomes part of the output circuit and is heated between the electrodes applied to opposite sides of the tumor. Tuned compensating coils in the paddle handles, a connector lead between the paddles, and a direct current inverse feed-back loop between the RF output and the crystal oscillator produce stable and readily controlled tumor heating. Over 200 subcutaneous rat tumors of different types, up to 3 ml in volume were heated at an intratumor temperature of 45 or 50°C for 15-30 min, with a regression rate of 100%. Twenty-five intramuscular VX2 tumors (10-25 ml) in rabbits were treated at

47-50°C for 30 min, with a 75% regression rate. There was no damage to normal tissues; temperature of the skin within the RF field remained 4-6°C below tumor temperature during the heating. The output of the RF machine did not exceed 15 W. The RF machine was also used clinically for the local heating of solid human tumors. Problems encountered with the high-intensity RF fields (up to 300 W) required and in the monitoring of tumor response, as well as a preliminary series of cases, are discussed.

5668 RESULTS OF COMBINED 434 MHZ E.M.W. AND X-RAY THERAPY (MEETING ABSTRACT). (Eng.) Holt, J. A. G. Inst. Radiotherapy and Oncology, Leederville, Western Australia, 6007 Australia). *Am J Roentgenol* 130(1): 191; 1978. (0 refs)

The results of combined microwaves and x-rays for the treatment of human cancer are presented. A dose of 434 MHz was applied approximately 15 min before the application of between 25 and 75 rads of x-rays. Microwave radiation was repeated on days 3 and 5, and at subsequent intervals during the course of daily x-ray therapy. On days on which microwave radiation was not delivered, conventional doses (i.e., 200-300 rads) of x-rays were applied. At 3-yr follow-up, 27 of 52 patients with ear, nose, and throat cancer were alive and well without evidence of local disease or neck metastases. Two patients with distant metastases in the chest underwent treatment with similar methods and remain well. Of 52 patients treated with air and hyperbaric therapy, 8 and 10 survive, respectively. For this group, combined treatment was three times more effective than conventional treatment. Other cancers that can be readily treated by this method include all normally treated by conventional therapy. Patients most suitable for this treatment include those with ear, nose, and throat cancer, primary glioma and lymphomas (all types). In addition, most types of breast, prostate, thyroid, kidney, and bladder cancer appear suitable. Based on radiowave absorption measurements, it is concluded that this treatment method selectively affects cancer cells in preference to normal cells.

5669 APPLICATOR DESIGN AND MICROWAVE FREQUENCY SELECTION FOR LOCAL HYPERHERMIA/WHOLE-BODY HYPERHERMIA EQUIPMENT SUITABLE FOR CLINICAL TREATMENT (MEETING ABSTRACT). (Eng.) Kowal, H. S. (Roswell Park Memorial Inst., Buffalo, NY 14240); Sandhu, T. S.; Johnson, R. J. R. *Am J Roentgenol* 130(1): 188; 1978. (0 refs)

Methods to achieve both local differential hyperthermia and whole-body hyperthermia were developed. To achieve local differential hyperthermia, microwave applicators were designed with sizes ranging from 10 x 10 cm to 1.5 x 1.5 cm, utilizing microwaves of either 2,450, 915, or 433 MHz. Single and multiple applicators of varying sizes were developed to achieve homogeneous tumor temperatures. Surface temperatures were monitored with both fiber optic and thermocouple probes, while depth monitoring was

accomplished with 30-gauge thermocouples placed perpendicular to the radio frequency field. Normal tissue cooling was achieved by either cooling the skin surface with cold air or by circulating liquid having the same dielectric constant as the tissue in a plastic bag positioned between the skin surface and the applicator. Temperature distribution data resulting from different applicator sizes and different frequencies was presented from both phantom and *in vivo* experiments. A whole-body hyperthermia system, suitable for clinical radiotherapy, also was developed. The system consisted of a NASA patch-type liquid-cooled garment (LCG) applied to the skin and covered with a polyethylene disposable shirt and pants. A specially tailored $\frac{1}{2}$ -inch neoprene skin diving suit was applied over the polyethylene for insulation. The patient was heated or cooled by a large capacity chiller-circulator connected to the LCG. Rapid initial heating was applied through two 915 MHz, 15 x 10 cm, microwave applicators positioned over the thighs.

5670 MICROWAVE RELAXATION EFFECTS OF NUCLEIC ACIDS AND NUCLEOTIDES (MEETING ABSTRACT). (Eng.) Krey, A. K. (Walter Reed Army Inst. Res., Washington, DC 20012). *Biophys J* 21(3): 112a; 1978. (0 refs)

Microwave relaxation effects of nucleic acids and nucleotides were investigated. It was shown previously that calf thymus DNA gradually decreased in permittivity (approaching ϵ' of its aqueous solvent) in the range 0.5 to 50 MHz. A dielectric dispersion was likewise observed in the same frequency range for transfer-RNA and for most of the mononucleotides of both nucleic acids. Of the nucleotides, adenosine monophosphate and deoxy adenosine monophosphate showed no dispersion, while relaxation effects increased progressively for cytidine 5'-monophosphate/dibutyl cytidine 5'-monophosphate, guanosine monophosphate/deoxy guanosine monophosphate, and uridine 5'-monophosphate-thymidine monophosphate with a specificity that was characteristic for the dipole moments of the respective nucleotide bases. Removal of bases increased the relaxations of nucleotides as did subsequent deletion of sugars so that phosphates alone showed the largest dispersion effects. Nucleotide dispersions also increased upon addition of phosphates or decreased when a phosphate group was removed. The findings suggest that configurational parameters of mononucleotides determine the relaxation effects of DNA and RNA and that the nucleotides' conformational properties may also be involved.

5671 ON THE ROLE OF ELECTRIC FIELDS IN PHOTO-INDUCED PRIMARY CHARGE SEPARATION (MEETING ABSTRACT). (Eng.) Yamamoto, T. (Dept. Chemistry, Cornell Univ., Ithaca, NY 14853); Albrecht, A. C. *Biophys J* 21(3): 195a; 1978. (0 refs)

The possible connection between high electric fields and efficient charge separation found in the photosynthetic system was explored and related literature was reviewed. The expected effects of

high electric fields on the yield of photoinduced primary charge generation have been demonstrated in two different organic systems. One consisted of a thin organic photoconducting film, electrostatically charged. The other was a cell having a thin polycrystalline chlorophyll-a film sandwiched between two different metals; a high internal field followed from the contact potential between the metal and the chlorophyll. In both cases the efficiency of photoinduced charge generation improved drastically as fields approached 10^6 V/cm. In photosynthesis the presence of a permanent electric field of about 10^6 V/cm has been implicated in the thylakoid membrane.

5672 ELECTROMAGNETIC HEATING TECHNIQUES (MEETING ABSTRACT). (Eng.) Hand, J. W. (Hammersmith Hosp., Du Cane Rd., London, W12, England). *Br J Radiol* 51(601): 74; 1978. (0 refs)

The band of frequencies in the electromagnetic spectrum that is used in heating tissues at depth is discussed. The methods traditionally used to couple energy into tissues are described, and the disadvantages of such methods to produce heating at depth are outlined. The possibility of producing internal hot spots in a target whose dimensions are comparable to the wavelength of the radiation and the relevance of this to the heating of small animals are discussed. Recent developments are outlined including contact applicators, which may be used at frequencies somewhat lower than the microwave diathermy frequency of 2.45 GHz, and an invasive technique, which avoids heating of superficial tissue by using needle electrodes to pass high frequency currents through deep tissue. Some of the problems associated with temperature measurement in the presence of electromagnetic fields are stated and new kinds of thermometers that enable reliable temperature measurements in such an environment are briefly described.

5673 THERMOCHEMOTHERAPY IN VIVO (MEETING ABSTRACT). (Eng.) Marmor, J. B. (Stanford Medical Center, Stanford, CA 94305); Hahn, G. M. *Proc Am Assoc Cancer Res* 19: 118; 1978. (0 refs)

An investigation was performed to test whether chemotherapy of solid tumors can be enhanced by local heating of tumor masses and whether non-tumocidal agents, such as, 2-aminoethylisothiouronium (AET) become tumocidal in the presence of local heat. C3H mice bearing the KHT mammary carcinoma, a drug resistant tumor of low immunogenicity, were utilized. Drugs were given intravenously and the tumors locally heated by radio frequency electromagnetic fields to 43°C for 30 min. Tumor growth delay (GD) and cure rate (CR) were followed. No systemic hyperthermia was obtained. For bleomycin, the effect of the combined modality was superior to either alone (GD=12 days versus 3 days; CR=40% versus 0%), provided drug and hyperthermia were administered simultaneously. If exposure to the two modalities was separated by 24 hr, no effect was seen, suggesting a true inter-

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action. For adriamycin (ADR) no clear-cut improvement in results was obtained even though ADR showed equal potentiation in vitro. Localized heating of tumor masses did not appear to cause AET to become tumoricidal in vivo. The results

suggest that localized heating may be a useful adjunct to chemotherapy of solid tumors. However, not all drugs that were potentiated by heat in vitro demonstrated the same effect when used against KHT tumors in vivo.

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